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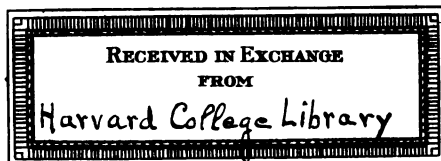
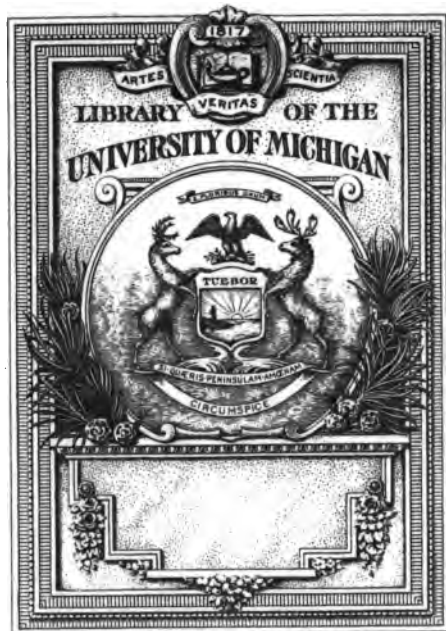
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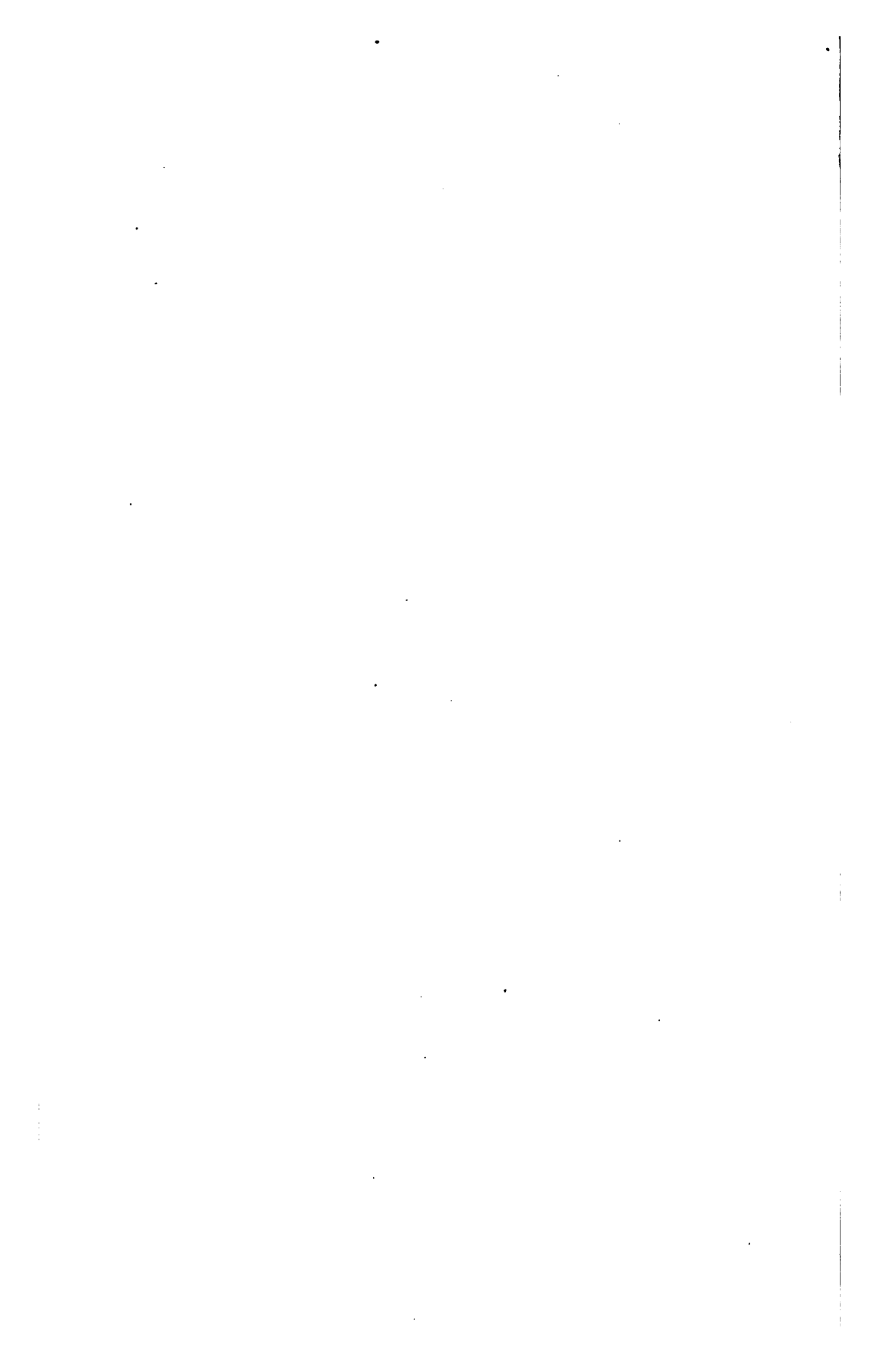


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SECOND ANNUAL REPORT

OF THE

*Masachusetts*

**METROPOLITAN WATER BOARD.**

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JANUARY 1, 1897.

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BOSTON:

WRIGHT & POTTER PRINTING CO., STATE PRINTERS,

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# METROPOLITAN WATER BOARD.

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*To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.*

The Metropolitan Water Board respectfully submits its report for the year 1896, being its

## SECOND ANNUAL REPORT.

The Metropolitan Water Board, established under chapter 488 of the Acts of the year 1895, began its work in July of that year. Its operations for the remainder of the year 1895 consisted chiefly in organizing its departments and entering upon the various surveys and investigations necessarily preliminary to the active work of construction which devolved upon the Board under the Act.

### I. ORGANIZATION.

#### (1) *Administration.*

The Board, as originally appointed by the Governor, consisted of Henry H. Sprague of Boston, chairman, Wilmot R. Evans of Everett, and John R. Freeman of Winchester. Mr. Freeman, on account of removal from the Commonwealth, resigned his position, his resignation taking effect on April 15, 1896. Henry P. Walcott, M.D., of Cambridge, was appointed in his stead, and was qualified for his duties and began his service on the Board on April 16, 1896.

William N. Davenport of Marlborough has continued as secretary and executive officer of the Board and Alfred F. Bridgman as auditor and accountant. The office force has further comprised a book-keeper, an assistant in auditing, two stenographers, a messenger and a janitor.

(2) *Engineering Department.*

The engineering department is organized with the following principal engineers :—

*Chief Engineer*, FREDERIC P. STEARNS.

*Consulting Engineers*, JOSEPH P. DAVIS, ALPHONSE FTELEY.

*Engineer of Distribution Department*, DEXTER BRACKETT.

*Engineer of Sudbury Department*, DESMOND FITZGERALD.

*Engineer of Dam and Aqueduct Department*, THOMAS F. RICHARDSON.

*Engineer of Reservoir Department*, HIRAM A. MILLER.

*Principal Office Assistant*, REUBEN SHIRREFFS.

Subordinates in the engineering force have numbered 150, and, in addition, inspectors of pipe making, pipe laying, masonry and earth work, to the number of 30, have been employed. Laborers to assist in the making of borings and for handling of water pipes, repairing of roads and other minor operations have been employed from time to time, the maximum number at any one time being 97.

The contractors for building the tunnel and aqueduct, for excavation of the soil and the preparation for use of Reservoir No. 5, and for laying the main distribution pipes, have employed a large number of men, amounting in the busiest period of the year to 4,108 men, using 845 horses.

(3) *Legal Services.*

On entering upon its work the Board secured the legal services of Albert E. Pillsbury and Andrew J. Bailey of Boston, and Frank P. Goulding of Worcester, and these gentlemen were of great assistance to the Board in the organization of its work, the preparation of contracts, and establishing the basis of negotiations and settlements. On Nov. 1, 1896, under the provisions of chapter 490 of the Acts of the year 1896, the Attorney-General of the Commonwealth assumed the performance of the legal work of the Board, and since that date the duties of counsel have been performed under his direction.

(4) *Conveyancing Department.*

The necessity for the examination of all of the titles of the lands taken for the aqueduct in Berlin, Northborough, Marlborough and Southborough, and the titles of the lands which are to be taken for the reservoir in Clinton, Boylston, West Boylston and Sterling, has

required a large amount of conveyancing. This work has been done under the supervision of Alfred C. Vinton, who has been assisted in the work of the Boston office by George D. Bigelow, and at the Worcester registry by Charles T. Davis. For the examination of titles, preparation of papers and other matters connected with conveyancing, ten assistants, including two stenographers and a messenger, have been employed. The larger part of the preliminary work of the examination of titles in the Worcester registry, for the aqueduct line and the site of the great reservoir, has been completed, and the titles of eighty-seven estates have been finally passed upon. A large amount of other work, pertaining to titles in Southborough and Marlborough and the various other sections of the Metropolitan Water District, has been accomplished.

(5) *Police.*

The Board being required to furnish, without charge, to all towns within which any work is done under the authority of the Act, such additional police protection as may be necessary in consequence of its work, has provided for the appointment of officers as follows:—

<i>Reservoir No. 5.</i>	
Southborough, . . . . .	14 officers.
Marlborough, . . . . .	8 “
<i>Nashua Reservoir and Aqueduct.</i>	
Clinton, . . . . .	3 officers.
Berlin, . . . . .	9 “
Northborough, . . . . .	6 “
Boylston and West Boylston, . . . . .	1 “
<hr/>	
Total number, . . . . .	41 “

The officers in Southborough are appointed, in accordance with an agreement made by the town with the city of Boston, by the selectmen of Southborough; and the officers in Marlborough are appointed by the mayor of that city, subject to the confirmation of this Board, and are under his supervision.

The officers in the towns of Clinton, Berlin and Northborough are appointed by the selectmen of the respective towns, with the consent of the Board. The force in the towns of Berlin and Northborough is under the direction of Isaac M. Drew as chief.

In addition, it was deemed desirable to have one officer for the towns of Boylston and West Boylston, although the work of construction has not been begun in these towns. For the purpose, Frank H. Baldwin, who is also a deputy sheriff for the county of Worcester, was designated, and he adds to his duties a general care of the property of the Board in these towns.

In comparison with the number of men employed under the various contracts in the districts where the work of construction is carried on, little disorder has arisen, and the officers have attempted to guard, as far as possible, the interests of the people of the districts.

#### *(6) Offices and Buildings.*

The office of the Board for administration purposes, the central and drafting offices of the engineering department, and the conveyancers' office have continued at No. 3 Mt. Vernon Street in Boston. A room in Worcester, in convenient connection with the registry of deeds, has been required for the use of the title examiners in Worcester County.

Branch offices of the engineering department have been maintained in Clinton, West Boylston, Northborough, Marlborough and Southborough.

The necessity for large accommodations, not only adequate for the performance of the work which is to be carried on in and about Clinton for several years to come, but also sufficiently fireproof to insure the safety of the various plans and surveys necessary to be kept in the vicinity of the dam and reservoir, required the erection of a new building at Clinton, as none adapted to the requirements of the Board could be found in that town. The Board accordingly purchased a lot at the corner of Walnut and Prospect streets, and is erecting a building which it is expected will be completed in a short time.

The headquarters of the police for the district of the Nashua Aqueduct have been maintained at West Berlin, in a building which has been leased for the purpose. The police headquarters at Fayville in Southborough, established by the city of Boston for the Reservoir No. 5 district, have been continued there in a building belonging to the Commonwealth.

The large amount of pipe required for the distribution lines has necessitated the establishment of three pipe yards for receiving and

storing the pipes before they are conveyed to the various points where they are laid. These pipe yards are (1) on the line of the Boston & Maine Railroad at Edgeworth in Malden, and (2) at Park Street in Somerville, and (3) at the end of Windsor Street on the boundary between Somerville and Cambridge on the line of the Fitchburg Railroad.

Temporary field offices have been erected at other places, as the exigencies of the work have demanded.

## II. DUTIES IMPOSED UPON THE BOARD.

The Act of the year 1895 required the Board to construct, maintain and operate a system of water works in accordance with plans and recommendations submitted by the State Board of Health in that year, and to provide thereby a sufficient supply of pure water for the cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop. Provision was also made for the admission into the Metropolitan Water District of other cities and towns any parts of which are within ten miles of the State House, for supplying water to water companies owning pipe and water systems in towns within said ten miles, and also for permitting the Board to furnish water to other cities and towns and water companies.

The principal features of the work required to be performed by the Board are the following:—

*First.*—The erection of a large dam and dikes at Clinton, and the construction upon the south branch of the Nashua River, in the towns of Clinton, Boylston, West Boylston and Sterling, of a storage reservoir having a capacity of about 63,000,000,000 gallons of water, and covering an area, exclusive of margins, of about 6½ square miles.

*Second.*—The building of an aqueduct capable of conveying daily 300,000,000 gallons of water, from the dam at Clinton, a distance of 12 miles, through the towns of Clinton, Berlin, Northborough, the city of Marlborough and the town of Southborough, to the new reservoir of the Sudbury water system in the town of Southborough and the city of Marlborough, known as Reservoir No. 5. This aqueduct embraces (1) a tunnel, through rock, 2 miles long; (2) a covered masonry aqueduct, 7 miles long, with a stone bridge cross-

ing the Assabet River; (3) an open channel, 3 miles long, substantially following the course of Stony Brook into the Reservoir No. 5.

*Third.* — The taking of the lands in and around Reservoir No. 5 in Southborough and Marlborough, and completing the construction of the reservoir which had been begun and nearly half finished by the city of Boston, — a reservoir which, when completed, is to cover an area of about 2 square miles, and to have a capacity of about 7,500,000,000 gallons of water.

*Fourth.* — The taking, on or before the first day of January in the year 1898, of all the lands and water works held by the city of Boston for the purpose of storing, preserving and supplying water, westward of the Chestnut Hill Reservoir in Boston, and westward of the pipes to be laid from the Chestnut Hill Reservoir to Spot Pond, including the pumping station at the Chestnut Hill Reservoir, and the lands under and surrounding the same.

*Fifth.* — The taking, on or before the first day of January in the year 1898, of Spot Pond, in the town of Stoneham and the city of Medford, and the lands under and surrounding the same, with the pumping stations thereon.

*Sixth.* — The building of new pumping stations at the Chestnut Hill Reservoir and in other parts of the Metropolitan Water District, as may be required.

*Seventh.* — The laying of great main distributing pipes from the Chestnut Hill Reservoir, to connect with Spot Pond and the various cities and towns constituting the Metropolitan Water District, for the distribution of the water to the various municipalities.

By the construction of these works it is proposed that the water of the Nashua water-shed, having an area of about 118 square miles, and capable of yielding, even in a series of very dry years, 105,000,000 gallons of water daily, shall be stored in the great reservoir on the south branch of the Nashua River; that the water shall be conveyed by the Nashua Aqueduct to the new Reservoir No. 5 in Southborough and Marlborough; and thence conveyed, with the mingled waters of the present Sudbury and Cochituate systems of the city of Boston, to the Chestnut Hill Reservoir and to Spot Pond, from which it shall be distributed to the various cities and towns of the Metropolitan Water District. The completion of this system would seem to insure to the District, in the most unfavorable seasons, a daily supply of at least 173,000,000 gallons of





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water, — a supply double that obtainable from all the sources combined now utilized for the cities and towns composing the Metropolitan Water District.

The accompanying plan, being Plan No. 1, shows the location of the projected Nashua Reservoir in Clinton, Boylston, West Boylston and Sterling, and the Nashua water-shed; the three sections of the Nashua Aqueduct in process of construction leading from the Nashua Reservoir to the Reservoir No. 5 in Southborough and Marlborough; Reservoir No. 5 and the completed basins of the Sudbury system, with the Sudbury water-shed; the Lake Cochituate and the Cochituate water-shed; the present Sudbury and Cochituate aqueducts, leading to the Chestnut Hill Reservoir; and the main pipe lines in process of construction from the Chestnut Hill Reservoir to Spot Pond.

### III. WORK OF CONSTRUCTION.

The first duty of the Board seemed to be to furnish an increased supply of water at the earliest possible period to the city of Boston and several others of the cities and towns constituting the Metropolitan Water District, in which the demand for water has nearly, if not quite, reached the supply of a year of moderate rainfall, and in which the supply of a dry year would be entirely inadequate to meet the demands. For this purpose the building of the Nashua Aqueduct, to connect the water of the Nashua River with the Sudbury system of Boston, the completion of the Reservoir No. 5, and the laying of the distributing main water pipes to connect the Chestnut Hill Reservoir with Spot Pond and the various cities and towns of the Metropolitan Water District, were pushed forward with all possible speed, and satisfactory progress has, on the whole, been made in these operations.

#### (1) *Nashua Aqueduct.*

The work of construction of the Nashua Aqueduct was begun early in the year 1896. The contracts for the building of the two miles of tunnel were awarded in February last. In May contracts were made for the seven miles of covered masonry aqueduct, in June for the construction of the bridge over the Assabet River, and in September for the construction of the open channel at the end of the Aqueduct.

The estimates for the construction of the Nashua Aqueduct, which formed the basis for awarding the contracts, independent of engineering and incidental charges, were as follows : —

Two miles of tunnel, . . . . .	\$370,826 00
Seven miles of covered masonry aqueduct, . . . . .	721,530 60
Bridge over the Assabet River, . . . . .	64,676 25
Three miles of open channel, . . . . .	89,470 00
Making a total of . . . . .	<u>\$1,246,552 85</u>

The amount paid by the Commonwealth to Dec. 1, 1896, on account of contracts, was \$204,522.61; for land damages, \$12,337.50; and for engineering and other expenses, \$81,834.36, — a total of payments amounting to \$298,694.47.

For the construction of the Nashua Aqueduct, 94 lots of land, belonging to 66 different owners, were taken, having a total area of 261.64 acres. Settlements have already been made with 16 of the owners.

The two miles of tunnel and the stone bridge over the Assabet River are both already more than half completed; and such progress has been made upon the various sections of the covered masonry aqueduct and the open channel as to lead to the assurance that the whole Aqueduct will be completed by the end of the year 1897, or early in the succeeding year, so that the water flowing in the south branch of the Nashua River may be diverted and conveyed through the Aqueduct to Reservoir No. 5.

The accompanying plan, being Plan No. 2, shows the three sections of the aqueduct and a profile of the elevation of the Aqueduct, and indicates the progress which has been attained.

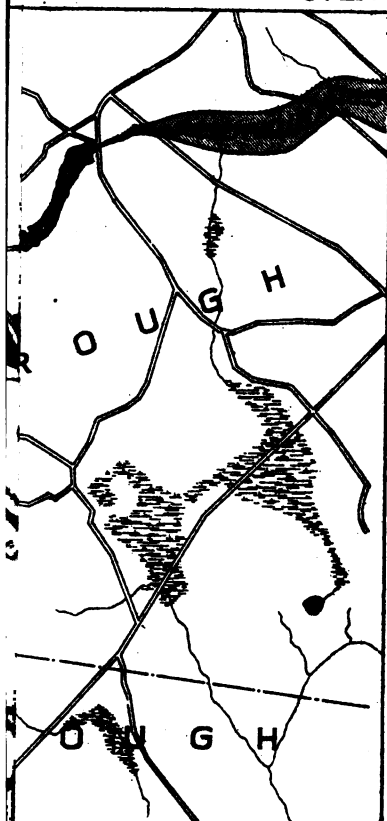
The accompanying Plan No. 3 gives sections of the Aqueduct, showing the different methods of construction on embankment and in excavation, and in rock and in earth. This plan also gives an elevation of the stone bridge across the Assabet River, with longitudinal and cross-sections, and indicates the progress of the work.

Tables giving the names of the various contractors, the estimated amount and estimated value of the work to be done under the contracts, and other details, will be found in the Appendix.

## (2) *Reservoir No. 5.*

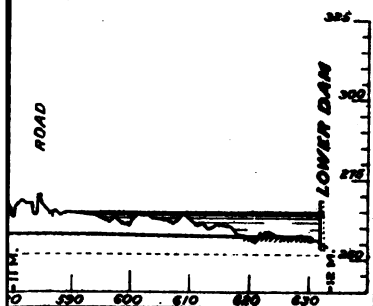
The lands in and immediately surrounding Reservoir No. 5, in the town of Southborough and the city of Marlborough, were taken

# PLAN No. 2.



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Geo. H. Walker & Co., Lith., Boston.



by the Board in behalf of the Commonwealth on Jan. 4, 1896, and the contracts for construction which had been made by the city of Boston and were in process of execution were assumed by the Board. The contracts made by the city of Boston provided for the building of the dam and the stripping and preparation of about one-half of the territory to be submerged in the reservoir.

The Metropolitan Water Act required that the city of Boston should be reimbursed for all moneys paid for land damages, or otherwise, in connection with the building of this reservoir, and for the lands taken for the protection of the purity of the water. The Board has accordingly examined and audited the accounts for the expenditures made by the city of Boston in the taking and purchase of lands and in the construction of the dam and reservoir, and has caused the city to be reimbursed by the payment of \$1,118,975.74.\* There are, in addition, some claims still unsettled on account of the lands which have been taken and the other operations of the city.

Contracts for the completion of the stripping and filling of the reservoir, to prepare it for the introduction of water, were made in April last, and work was immediately begun under them by the various contractors. The dam is nearly finished, and several of the contracts for the preparation of the reservoir, which were made by the city of Boston, have already been completed.

Inasmuch as the location of the New York, New Haven & Hartford Railroad runs through the reservoir, it was necessary, in order to connect the separated portions, to construct a new stone arch bridge near Fayville in Southborough, and somewhat to widen the embankment of the road bed and to riprap the slopes. This work was undertaken and vigorously prosecuted to completion at a total cost of \$33,400.21.

Considerable work has been required to complete the new highways, whose construction the city of Boston had undertaken, in order to supply the place of the several miles of roads in Southborough and Marlborough, within the limits of the reservoir, which had been discontinued.

Such progress has been made in the performance of the various contracts still pending that it is believed that the completion of the dam and reservoir early in the year 1898 is assured.

---

\* The final payment of \$518,975.74 was made to the city of Boston in December, 1896.

Estimates of the sums which will be required to be paid under the various contracts for building the dam and constructing the reservoir, based upon the work already performed and that which is still to be done, amount to a total sum of \$1,852,624.25. The sum paid by the city of Boston on account of the taking and purchase of lands for the reservoir and of other land damages, together with the estimated sum due on account of unsettled land claims, and including engineering and incidental expenses, amounts to about \$800,000, so that it is estimated that the total cost of Reservoir No. 5 will somewhat exceed \$2,600,000. In addition to the \$1,118,975.74 paid in reimbursement to the city of Boston, the payments by the Commonwealth on account of Reservoir No. 5 up to Dec. 1, 1896, have amounted to \$747,025.20, and the total of the payments made has been \$1,347,025.20.

The various sections of the reservoir and the progress made toward the completion of the work, with diagrams showing the method of construction of the dam and the system adopted for the preparation of the reservoir for the introduction of water, are represented on the accompanying plan, being Plan No. 4.

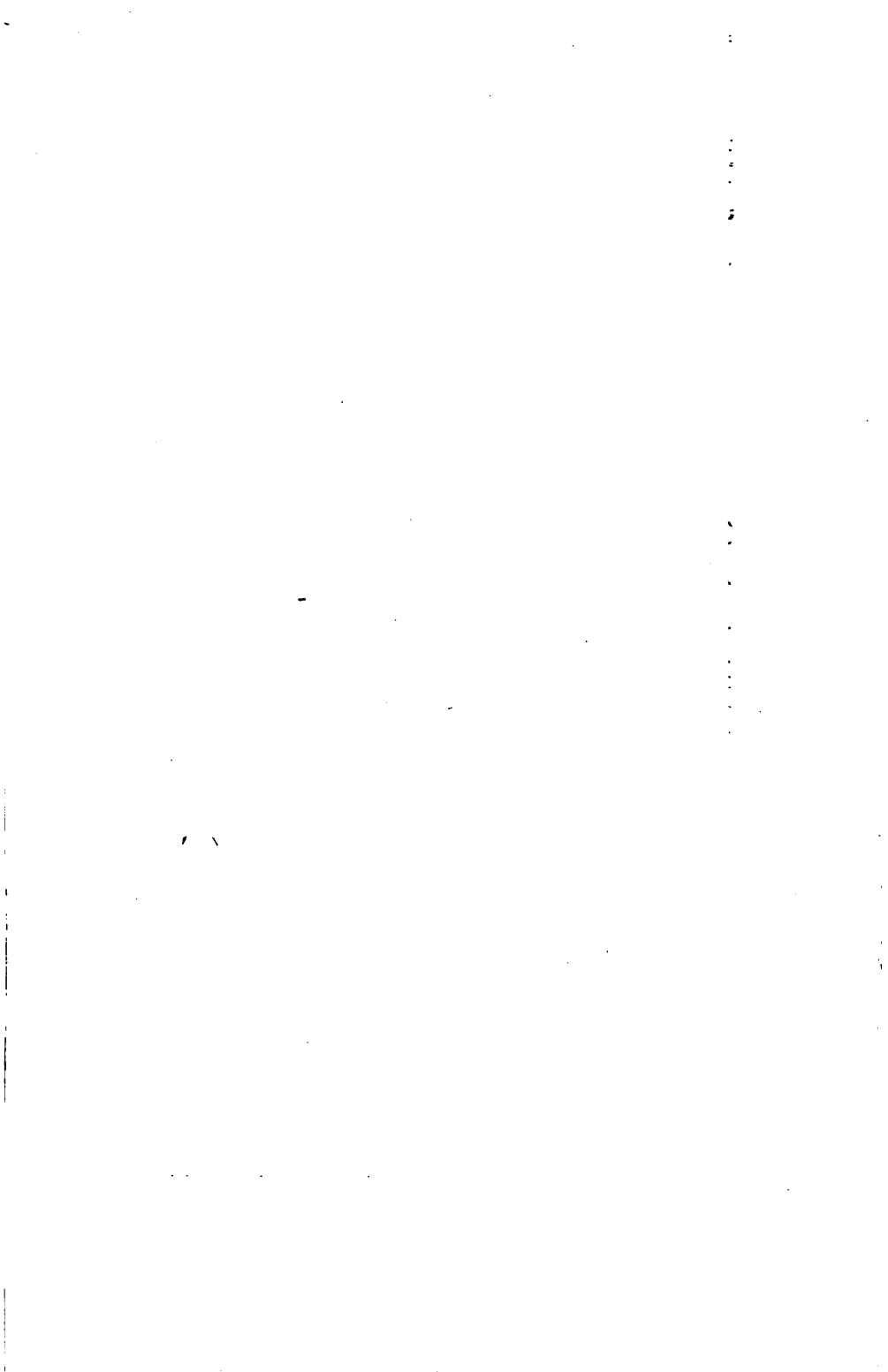
Tables showing the names of the various contractors, the estimated amount and value of the work to be done, and the amount completed in December, 1896, will be found in the Appendix.

As the lower portions of the reservoir are prepared to receive the water, the work of filling the reservoir will soon be begun, and it is believed that sufficient water will be collected the present season so that, in case the necessity therefor shall arise in the coming summer, a substantial addition may be afforded to the existing supply of the city of Boston.

### (3) *Main Distributing Pipe Lines.*

Two main lines of 48-inch cast-iron pipes are projected to be laid from the Chestnut Hill Reservoir to Spot Pond, which is to be used as a storage and distributing reservoir for the city of Boston and other lower portions of the Metropolitan Water District. Pipes 48 inches in diameter and pipes of lesser dimensions are also to be laid to connect with the various cities and towns in the Metropolitan District.

The first contract for the manufacture of the pipes was made on Dec. 27, 1895, and subsequent contracts have from time to time







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been made for furnishing additional pipes, to an amount in all of 42,920 tons. More than two-thirds of the pipes estimated as necessary have already been contracted for, and a large portion of this amount has been delivered.

The work of laying the pipes was begun in May last. Contracts have been made for laying nearly the whole length of one of the main lines from Chestnut Hill Reservoir to Spot Pond, extending through Brookline, Brighton, Cambridge, Somerville, Medford, Malden, Melrose and Stoneham. Permission to cross the Charles and Mystic rivers was given by the Board of Harbor and Land Commissioners of the Commonwealth, and was also, on recommendation of Col. S. M. Mansfield, U. S. A., accorded by the Secretary of War. The larger part of this line has already been completed. Contracts have also been made for laying branch pipe lines in Medford and Malden, and in Everett, Chelsea and Revere, and a considerable portion of the work under these contracts has been finished. A portion of the second main line to Spot Pond has also been laid. The pipes already laid extend a distance of about 15 miles.

The contracts for furnishing pipes, according to estimates based upon those already furnished and the approximate value of those still to be furnished, amount to \$869,424.86. The approximate amount of contracts made for the laying of pipes, under a similar estimate, is \$166,836.33. Miscellaneous contracts in connection with pipe lines amount to \$18,279.59. The total amount of contracts for the distributing system is \$1,054,540.78. Payments made on contracts for pipes and valves up to Dec. 1, 1896, amount to \$535,109.40, and on contracts for pipe laying amount to \$116,881.83.

There is little doubt but that at the end of the year 1897 the Chestnut Hill Reservoir and Spot Pond will be connected by one of the main lines, and connections will be made from the Chestnut Hill Reservoir or Spot Pond with the most of the cities and towns in the Metropolitan Water District.

The accompanying plan, being Plan No. 5, shows the location of the various pipe lines, the different dimensions of the pipes, the portions contracted for, both laid and not laid, and other lines projected, with the character of the service and other details.

There will be found in the Appendix the details of the various contracts made for furnishing and for laying the pipes and valves and for the miscellaneous work.

(4) *Nashua Dam and Reservoir.*

No taking has as yet been made of the waters of the south branch of the Nashua River, nor have any of the lands to be included in the Nashua Reservoir been taken under the Act authorizing the taking of the waters and lands.

The surveys and investigations necessarily preliminary to the construction of the dam in Clinton and the Nashua Reservoir have been pushed forward as fast as possible; but they have not reached such a degree of completion as to permit the making of definite plans and specifications; and consequently the time has not yet been reached when a satisfactory taking of the waters and lands can be made.

Negotiations, however, have not only been carried on for the settlement of the damages to the various mill properties in the basin of the Reservoir, but also the claims for damages for water to be diverted have been considered, and in some cases settlements have been effected. Inasmuch, also, as it has not seemed proper for the Board yet to make the taking, under the right of eminent domain contemplated by the Act, it has been the policy of the Board to enter into negotiations with all parties who desire to meet it, and who desire for any reasons to surrender their properties before the takings are made. It is believed that in this way not only the requirements of the Board will be better satisfied, but also that the convenience and best interests of the parties who are to suffer from the loss of their estates will be better subserved than by a summary taking and divesting of ownership or occupation.

Settlements have been effected with the West Boylston Manufacturing Company and the Clarendon Mills of West Boylston, and the properties of both these corporations have been conveyed to the Commonwealth. The corporations are permitted, however, under the agreement made, to occupy their estates for a considerable period, or until they shall be needed for the purposes of the work. The number of acres conveyed to the Commonwealth by these corporations was 260.

A settlement has also been effected with the Locks and Canals Company of Lowell and the Essex Company of Lawrence for the damages which will be occasioned by the diversion of the water of the Nashua River.

Purchases have been made from 54 private parties of estates in Boylston, West Boylston, Clinton and Sterling, situated within the



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proposed limits of the Reservoir. These purchases include both village property and farms, and also the Catholic churches in West Boylston and Boylston, and comprise an area of about 950 acres.

The amount paid to Dec. 1, 1896, for lands, buildings and water rights in connection with the reservoir has been \$863,164, and the conveyances embrace an area of 1,210 acres. An additional amount of \$203,000 was paid on account of damages for the diversion of water.

Borings and other investigations have been constantly in progress, in order to ascertain the best location for the main dam and also for the north and south dikes. Good progress has been made in both directions, and it is believed that the work preliminary to the construction of the dam can be entered upon during the coming season, and that plans and specifications can also be made and contracts for construction awarded.

Considerable progress has also been made in the surveys for the relocation of the various roads in the towns in which the Reservoir is to be constructed. Plans have already been nearly completed for the laying out of the new road to take the place of the river road, so called, running from Clinton through Boylston Centre to Worcester, and its route will probably be definitely determined and its construction be begun early in the year 1897.

Surveys have been made for the relocation of the Central Massachusetts division of the Boston & Maine Railroad, but no definite action has been taken. No disturbance will be made for a considerable period of time of the present location of the railroad.

#### (5) *Spot Pond and Vicinity.*

Many surveys and investigations have been made of the territory surrounding Spot Pond in order to ascertain what work shall be necessary in order to adapt it to the purposes of a storage and distributing reservoir, and investigations have also been carried on and plans have been completed for the purpose of determining the most feasible routes for the water pipes through the Middlesex Fells, now embraced within the limits of the metropolitan park system. Borings and other examinations have been carried on in the Fells for definitely determining the best location of the high-service reservoir, which was contemplated to be built in the Fells. The various investigations will be continued and will probably all be finished in the coming year.

(6) *Pumping Station at Chestnut Hill.*

The necessity of providing at an early date for a pumping engine for the high service, to be used in connection with the present pumping engine at the Chestnut Hill station, in Boston, has caused the Board, after careful and thorough investigations, to arrange for a contract with the Edward P. Allis Company of Milwaukee, Wis., for the building of a pumping engine having a capacity to lift 30,000,000 gallons of water per day. It is the intention of the Board that the engine shall be completed and placed in position by the middle of the year 1898.

IV. THE ADMISSION OF OTHER MUNICIPALITIES INTO THE METROPOLITAN WATER DISTRICT.

In accordance with the application made by the city of Quincy, investigations have been made as to the proper method of furnishing that city with a sufficient supply of water. It was found desirable, instead of erecting a large tank on Forbes Hill in that city, to erect a small standpipe and reservoir in that location, which should be sufficient to provide for a storage of water sufficient to meet the demands of any emergency which might occur.

Negotiations with that end in view have accordingly been in progress with the mayor and city council of that city, and arrangements have been effected by which it is anticipated that the city of Quincy will be admitted into the Metropolitan Water District at an early date.

Conferences have been had with representatives of several of the other municipalities lying within ten miles of the State House, and not now included in the Metropolitan Water District, and in one or two instances with representatives from towns situated more remote from the State House, in relation to their admission into the district or to their obtaining a supply of water from the new system, but no definite action has as yet been taken by any of these municipalities.

V. FINANCIAL STATEMENT.

The Board presents in abstract, as required by the act of the Legislature, the following accounts of its expenditures and disbursements, receipts, assets and liabilities.

*(1) Expenditures.*

The total amount of expenditures for the year ending Nov. 30, 1896, is \$3,563,818.58, and the total amount from the time of the organization of the Board, July 19, 1895, is \$3,613,310.33. The general character of these expenditures is as follows:—

	For the Year ending Nov. 30, 1896.	From the Beginning of the Work to Dec. 1, 1896.
<i>Administration.</i>		
Commissioners, . . . .	\$15,166 67	\$19,533 60
Secretary and auditor, . . . .	6,175 00	7,615 33
Clerks and stenographers, . . . .	4,309 95	5,119 02
Legal services, . . . .	2,334 00	2,334 00
Travelling, . . . .	132 68	163 59
Stationery and printing, . . . .	1,358 76	1,768 60
Postage, express and telegrams, . . . .	255 35	287 25
Furniture and fixtures, . . . .	359 60	2,504 14
Alterations and repairs of building, . . . .	75 09	1,506 31
Telephone, lighting, heating, water and care of building, . . . .	808 50	1,138 18
Miscellaneous expenses, . . . .	480 40	742 11
	\$31,456 00	\$42,712 13
<i>Engineering.</i>		
Chief engineer and department en- gineers, . . . .	\$19,483 28	\$24,219 84
Principal assistant engineers, . . . .	14,627 85	15,216 56
Engineering assistants, . . . .	89,852 44	101,928 46
Consulting engineers, . . . .	5,361 10	5,361 10
Inspectors, . . . .	19,340 96	19,340 96
Railroad and street-car travel, . . . .	3,238 38	4,126 44
Wagon hire, . . . .	2,155 11	2,492 96
Stationery and printing, . . . .	4,083 13	4,433 28
Postage, express and telegrams, . . . .	896 72	994 23
Engineering and drafting instru- ments and tools, . . . .	5,649 83	9,851 48
Engineering and drafting supplies, . . . .	4,859 69	5,929 48
Books, maps and photographic sup- plies, . . . .	864 14	1,199 81
Furniture and fixtures, . . . .	3,586 68	7,763 58
Alterations and repairs of building, — main office, . . . .	208 94	2,154 94
Alterations and repairs of building, — sub-offices, . . . .	16 06	16 06
Telephone, lighting, heating, water and care of building,— main office, . . . .	1,349 57	1,372 45
Telephone, lighting, heating, water and care of building,— sub-offices, . . . .	1,605 11	1,637 46
Rent of offices and other buildings, . . . .	1,076 78	1,205 43
<i>Amounts carried forward,</i> . . . .	\$178,255 77	\$209,244 52
	\$31,456 00	\$42,712 13



	For the Year ending Nov. 30, 1896.		From the Beginning of the Work to Dec. 1, 1896.	
<i>Amounts brought forward,</i>	\$178,255 77	\$31,456 00	\$209,244 52	\$42,712 13
<i>Engineering — Con.</i>				
Field offices and sheds, . . .	449 77		449 77	
Clinton office building, . . .	3,636 02		3,636 02	
Unclassified supplies, . . .	2,651 29		3,296 31	
Miscellaneous expenses, . . .	1,763 68		2,307 39	
		186,756 53		218,934 01
<i>Construction.</i>				
Preliminary work (borings, sound- ings, test pits and other investi- gations) :—				
Advertising, . . . . .	\$1,419 26		\$1,419 26	
Labor, . . . . .	20,669 28		23,779 91	
Medical service, analyses, etc., . .	410 83		433 83	
Travelling, . . . . .	643 97		710 72	
Rent, . . . . .	23 00		28 00	
Water rates, . . . . .	772 77		897 81	
Freight and express, . . . .	187 78		239 36	
Jobbing and repairing, . . . .	232 29		316 29	
Tools, machinery, appliances and hardware supplies, . . . .	10,808 15		12,200 20	
Castings and iron work, . . . .	34 85		70 87	
Iron pipe and valves, . . . .	1,439 00		1,896 85	
Blasting supplies, . . . . .	23 35		31 60	
Paint and coating, . . . . .	117 81		123 81	
Fuel, oil and waste, . . . . .	263 84		263 84	
Lumber and field buildings, . . .	3,289 54		3,634 55	
Brick, cement and stone, . . . .	17 59		53 59	
Sand, gravel and filling, . . . .	157 55		157 55	
Unclassified supplies, . . . .	366 86		597 82	
Miscellaneous expenses, . . . .	41 30		41 30	
		40,939 02		46,897 16
Contracts, Nashua Aqueduct :—				
E. D. Smith & Co., Section 2,	\$24,525 00		\$24,525 00	
E. D. Smith & Co., Section 3,	38,389 50		38,389 50	
Silvio Casparis, . Section 4,	9,803 12		9,803 12	
Silvio Casparis, . Section 5,	10,279 08		10,279 08	
Silvio Casparis, . Section 6,	8,747 73		8,747 73	
Silvio Casparis, . Section 7,	15,709 77		15,709 77	
Jones, Pollard & Co., Section 8,	17,676 98		17,676 98	
Silvio Casparis, . Section 9,	14,712 91		14,712 91	
Silvio Casparis, . Section 10,	63,699 32		63,699 32	
Moulton & O'Mahoney, Section 11,	979 20		979 20	
		204,522 61		204,522 61
Contracts, Sudbury department :—				
Moulton & O'Mahoney, Dam No. 5,	\$211,329 60		\$211,329 60	
Auguste Saucier, . Section A,	681 99		681 99	
Moulton & O'Mahoney, Section B,	40,304 58		40,304 58	
<i>Amounts carried forward,</i>	\$252,316 17	\$463,674 16	\$252,316 17	\$513,065 91

	For the Year ending Nov. 30, 1896.		From the Beginning of the Work to Dec. 1, 1896.	
<i>Amounts brought forward,</i>	\$252,316 17	\$463,674 16	\$252,316 17	\$513,065 91
<i>Construction — Con.</i>				
Contracts, Sudbury departm't — <i>Con.</i>				
Malone & Strang, . Section C,	50,616 25		50,616 25	
Auguste Saucier, . Section D,	28,499 82		28,499 82	
Charles Linehan, . Section E,	23,123 90		23,123 90	
Newell & Snowling, Section F,	18,093 37		18,093 37	
Charles Linehan, . Section G,	11,009 56		11,009 56	
Moulton & O'Mahoney, Section H,	24,977 42		24,977 42	
Harry P. Nawn, . Section I,	36,561 68		36,561 68	
Moulton & O'Mahoney, Section J,	29,764 62		29,764 62	
Blagen & Bush, . Section K,	21,901 18		21,901 18	
Moulton & O'Mahoney, Section L,	22,701 12		22,701 12	
Harry P. Nawn, . Section M,	20,538 38		20,538 38	
Thos. Nevins & Son, Section N,	37,249 38		37,249 38	
Washburn & Washburn, Section O,	19,136 78		19,136 78	
Harry P. Nawn, . Section P,	26,820 75		26,820 75	
Washburn & Washburn, Section Q,	30,264 54		30,264 54	
Henry Parsons, . Iron fence,	5,142 54		5,142 54	
John Berry, . . . Filter beds,	896 79		896 79	
Holbrook, Cabot & Daly, Stone arch bridge,	20,549 43		20,549 43	
New York, New Haven & Hart- ford Railroad Company, Tem- porary bridge,	3,731 06		3,731 06	
		683,894 74		683,894 74
Contracts, distribution department:—				
Curnan & Hochstadter, Section 2,	\$39,517 92		\$39,517 92	
Snyder & Williams, Sections 4 and 11,	24,600 84		24,600 84	
D. F. O'Connell, . Section 6,	13,744 70		13,744 70	
C. H. Eglee Company, Sections 7 and 13,	21,330 83		21,330 83	
Collins & Ham, . Section 14,	2,513 53		2,513 53	
J. H. McKnight, . Section 15,	10,538 43		10,538 43	
George Goodhue, . Section 16,	2,516 87		2,516 87	
Collins & Ham, . Section 18,	2,118 71		2,118 71	
R. D. Wood & Co., Iron pipes,	207,419 30		207,419 30	
McNeal Pipe and Foundry Com- pany, . . . Iron pipes,	153,990 07		153,990 07	
Warren Foundry and Machine Company, . . . Iron pipes,	107,829 91		107,829 91	
Howard Harrison Iron Company, Iron pipes,	63,593 82		63,593 82	
Josiah H. Long, . . Valves,	2,276 30		2,276 30	
New Jersey Steel and Iron Com- pany, . . . Steel work,	1,041 00		1,041 00	
Chelmsford Foundry Company, Castings,	733 59		733 59	
		653,765 82		653,765 82
<i>Amounts carried forward,</i>		\$1,601,334 72		\$1,850,726 47

	For the Year ending Nov. 30, 1896.	From the Beginning of the Work to Dec 1, 1896.
<i>Amounts brought forward,</i>	\$1,801,334 72	\$1,850,726 47
<i>Construction — Con.</i>		
Additional work :—		
Labor, . . . . .	\$10,035 38	\$10,035 38
Medical service, . . . . .	6 00	6 00
Travelling, . . . . .	140 14	140 14
Rent, . . . . .	300 00	300 00
Water rates, . . . . .	4 50	4 50
Freight and express, . . . . .	239 80	239 80
Jobbing and repairing, . . . . .	294 38	294 38
Tools, machinery, appliances and hardware supplies, . . . . .	1,524 97	1,524 97
Castings and iron work, . . . . .	502 99	502 99
Iron pipe and valves, . . . . .	1,277 19	1,277 19
Paint and coating, . . . . .	1,057 89	1,057 89
Fuel, oil and waste, . . . . .	12 63	12 63
Lumber and field buildings, . . . . .	1,561 40	1,561 40
Drain pipe, . . . . .	73 69	73 69
Brick, cement and stone, . . . . .	227 80	227 80
Sand, gravel and filling, . . . . .	363 90	363 90
Municipal and corporation work,	2,249 80	2,249 80
Police service, . . . . .	19,950 36	19,950 36
Sanitary inspection, . . . . .	1,577 75	1,577 75
Unclassified supplies, . . . . .	89 05	89 05
Miscellaneous expenses, . . . . .	64 61	64 61
	41,554 23	41,554 23
Legal and expert services, . . . . .	3,277 32	3,277 32
<i>Real Estate.</i>		
Legal and expert :—		
Counsel and assistants, . . . . .	\$4,295 31	\$4,295 31
Conveyancer and assistants, . . . . .	14,185 19	14,185 19
Experts, . . . . .	4,875 12	4,875 12
Appraisers, . . . . .	464 78	464 78
Conveyancing supplies, . . . . .	1,024 47	1,024 47
Conveyancing expenses, . . . . .	424 32	424 32
Miscellaneous expenses, . . . . .	60 95	60 95
Settlements, . . . . .	877,988 00	877,988 00
Taxes and tax equivalents, . . . . .	1,626 02	1,626 02
Care and disposal, . . . . .	313 58	313 58
	905,257 74	905,257 74
<i>Damages.</i>		
Legal services, . . . . .	1,130 67	1,130 67
<i>Claims on Account of Diversion of Water.</i>		
Legal services, . . . . .	\$3,749 98	\$3,749 98
Expert services, . . . . .	2,970 41	3,070 41
Settlements, . . . . .	203,000 00	203,000 00
	209,720 39	209,820 39
<i>Amounts carried forward,</i>	\$2,962,275 07	\$3,011,766 82

	For the Year ending Nov. 30, 1896.	From the Beginning of the Work to Dec. 1, 1896.
<i>Amounts brought forward,</i> . . . . .	\$2,962,275 07	\$3,011,766 82
<i>Purchase of Water Works.</i>		
Legal and expert:—		
Legal services, . . . . .	\$1,538 51	\$1,538 51
Miscellaneous expenses, . . . . .	5 00	5 00
Reimbursement, city of Boston (for Reservoir No. 5),* . . . . .	600,000 00	600,000 00
	601,543 51	601,543 51
<b>Total,</b> . . . . .	<b>\$3,563,818 58</b>	<b>\$3,613,310 33</b>

The expenditures have been distributed among the various objects or works as follows:—

	For the Year ending Nov. 30, 1896.	From the Beginning of the Work to Dec. 1, 1896.
General administration, applicable to all parts of the work, . . . . .	\$31,456 00	\$42,712 13
<i>Nashua Dam and Reservoir.</i>		
Main dam, engineering, . . . . .	\$9,512 67	\$12,191 35
preliminary work, . . . . .	17,490 88	22,248 51
North dike, engineering, . . . . .	2,539 31	2,759 31
preliminary work, . . . . .	6,727 91	6,727 91
South dike, engineering, . . . . .	395 67	480 67
preliminary work, . . . . .	2,370 68	2,370 68
Removal of soil, engineering, . . . . .	4,794 44	6,175 94
preliminary work, . . . . .	879 15	879 15
Relocation of railroads, engineering, . . . . .	1,001 11	1,387 61
Roads and bridges, engineering, . . . . .	2,285 64	2,465 64
Real estate:—		
Engineering, . . . . .	19,705 35	22,166 76
Legal and expert, . . . . .	16,286 10	16,286 10
Mill property and water rights, . . . . .	765,000 00	765,000 00
Other property for reservoir and margins:—		
Clinton, . . . . .	17,350 00	17,350 00
Boylston, . . . . .	19,905 00	19,905 00
West Boylston, . . . . .	55,325 00	55,325 00
Sterling, . . . . .	675 00	675 00
Outlying property:—		
Clinton, . . . . .	3,609 00	3,609 00
Boylston, . . . . .	370 00	370 00
West Boylston, . . . . .	930 00	930 00
<i>Amounts carried forward,</i> . . . . .	\$947,152 91    \$31,456 00	\$959,303 63    \$42,712 13

\* The additional sum of \$518,975 74 was paid to the city of Boston in December, 1896.

	For the Year ending Nov. 30, 1896.		From the Beginning of the Work to Dec 1, 1896.	
<i>Amounts brought forward,</i> . . .	\$947,152 91	\$31,456 00	\$959,303 63	\$42,712 13
<i>Nashua Dam and Reservoir — Con.</i>				
Real estate — <i>Con.</i>				
Taxes, care and disposal, . . .	166 72		166 72	
Legal and expert (except in real estate), . . . . .	1,130 67		1,130 67	
		948,450 30		960,601 02
<i>Nashua Aqueduct.</i>				
Engineering, . . . . .	\$50,930 25		\$60,990 18	
Legal and expert, . . . . .	8,311 65		8,311 65	
Preliminary work, . . . . .	2,256 50		3,426 01	
Contracts :—				
Masonry in tunnel, . . . . .	56,450 04		56,450 04	
Masonry in trench, . . . . .	129,416 39		129,416 39	
Assabet bridge, . . . . .	17,676 98		17,676 98	
Open channel, . . . . .	979 20		979 20	
Additional work, . . . . .	8,903 77		8,903 77	
Real estate :—				
Property in Berlin, . . . . .	5,125 00		5,125 00	
Property in Clinton, . . . . .	5,600 00		5,600 00	
Property in Northborough, . . . . .	362 50		362 50	
Property in Marlborough, . . . . .	550 00		550 00	
Property in Southborough, . . . . .	700 00		700 00	
Care and disposal, . . . . .	202 75		202 75	
		287,465 03		293,694 47
<i>Dam and Reservoir No. 5.</i>				
Dam :—				
Engineering, . . . . .	\$9,019 39		\$9,019 39	
Preliminary work, . . . . .	464 22		464 22	
Contracts, . . . . .	211,329 60		211,329 60	
Additional work, . . . . .	2,677 82		2,677 82	
Reservoir :—				
Engineering, . . . . .	29,836 92		29,836 92	
Preliminary work, . . . . .	333 12		333 12	
Contracts, . . . . .	471,668 35		471,668 35	
Additional work, . . . . .	16,548 84		16,548 84	
Protection and improvement of sup- ply :—				
Engineering, . . . . .	851 63		851 63	
Contracts, . . . . .	896 79		896 79	
Additional work, . . . . .	91 27		91 27	
Real estate: taxes, care and dis- posal, . . . . .	1,570 13		1,570 13	
Legal and expert, . . . . .	1,737 12		1,737 12	
Reimbursement, city of Boston,* . .	600,000 00		600,000 00	
		1,347,025 20		1,347,025 20
<i>Amounts carried forward,</i> . . . . .		\$2,614,396 53		\$2,649,032 82

\* The additional sum of \$518,975.74 was paid to the city of Boston in December, 1896.

	For the Year ending Nov. 30, 1896.	From the Beginning of the Work to Dec. 1, 1896.
<i>Amounts brought forward,</i>	\$2,614,396 53	\$2,649,032 82
<i>Distribution System.</i>		
Low service:—		
Pipe lines, engineering, . . .	\$31,240 52	\$42,038 76
preliminary work, . . .	8,032 74	8,056 74
contracts, . . .	441,334 27	441,334 27
additional work, . . .	11,116 93	11,116 93
Pumping station, engineering, . .	1,920 09	2,665 12
preliminary work, . . .	8 00	8 00
Reservoir, Spot Pond, engineering, . . .	2,947 10	3,017 10
preliminary and additional work, . . .	560 21	560 21
Real estate, Boston, . . .	2,486 50	2,486 50
Legal and expert, . . .	1,541 66	1,541 66
Northern high service:—	501,188 02	512,825 29
Pipe lines, engineering, . . .	\$8,155 74	\$9,491 18
preliminary work, . . .	1,366 37	1,373 37
contracts, . . .	69,631 99	69,631 99
additional work, . . .	1,546 62	1,546 62
Pumping station, engineering, . . .	557 83	849 06
preliminary and additional work, . . .	31 00	31 00
Reservoir, Middlesex Fells, engineering, . . .	2,611 11	2,712 91
preliminary work, . . .	483 82	483 82
Legal and expert, . . .	132 78	132 78
Southern high service:—	84,517 26	86,252 73
Pipe lines, engineering, . . .	\$1,391 88	\$1,803 20
Pumping station, engineering, . .	453 40	568 40
Reservoir, Quincy, engineering and preliminary, . . .	638 18	730 68
Legal and expert, . . .	1,948 33	1,948 33
Extra high service, engineering, . . .	4,431 79	5,050 61
Pipes, valves, castings, etc., at stock yards, on hand November 30, . . .	286 73	375 73
	143,315 86	143,315 86
<i>Claims on Account of Diversion of Water.</i>		
Engineering, . . .	\$5,734 67	\$6,320 17
Legal and expert, . . .	6,720 39	6,820 39
Settlements, . . .	203,000 00	203,000 00
<i>Examination of Existing Water Works.</i>	215,455 06	216,140 56
Engineering, . . .	\$34 00	\$123 40
Legal and expert, . . .	193 33	193 33
	227 33	316 73
Total expenditures, . . .	\$3,563,818 58	\$3,613,310 33

*(2) Receipts.*

The total amount of receipts from rents, sales of property, etc., from Jan. 4, 1896, to Nov. 30, 1896, was \$3,400.57. The sources of these receipts are as follows:—

Forfeiture for contract awarded but not executed, . . . . .	\$500 00
Rentals from real estate, . . . . .	2,047 65
Sale of real estate and buildings, . . . . .	459 00
Land products, . . . . .	321 25
Labor, tools, supplies, etc., . . . . .	72 67
	<hr/>
	\$3,400 57

The foregoing receipts have been credited to the various objects or works as follows:—

Southborough Dam and Reservoir, . . . . .	\$2,037 85
Nashua Dam and Reservoir, . . . . .	783 84
Nashua-Sudbury Aqueduct, . . . . .	78 88
Distribution system, low service, . . . . .	500 00
	<hr/>
	\$3,400 57

*(3) Assets.*

The value of the assets is given, as far as practicable, at cost prices:—

Desks, chairs, safes, drafting tables, plan cases, type-writing machines, electrical fittings and general office furniture and fixtures, . . . . .	\$12,000 00
Record books, stamps, stationery and general office implements and supplies, . . . . .	2,800 00
Transits, levels, planimeters, scales and other engineering instruments; drafting paper and general drafting supplies; outfits for cement testing, blue printing, photography, etc., . . . . .	16,400 00
Atlases, maps, portfolios and reference books, . . . . .	700 00
Railroad and electric road tickets, . . . . .	1,000 00
Horses, vehicles and stable supplies, . . . . .	1,500 00
Revolvers, handcuffs, belts and other police supplies, . . . . .	500 00
Engines, pumps, boilers, derricks, diamond and other drills, lumber, field buildings, tools and general construction supplies, . . . . .	15,800 00
Stock for construction work (iron pipes, valves, man-hole castings, etc.), . . . . .	142,800 00
	<hr/>
	\$193,500 00

There are numerous note and calculation books, studies, plans, etc., of great value to the Board, to which no stated value can be assigned; also real estate in the proposed Nashua Reservoir; the nearly completed dam and the partially completed reservoir in Southborough and Marlborough; a portion of the Nashua Aqueduct; and several miles of pipe line.

(4) *Liabilities.*

Unpaid bills, . . . . .	\$8,300 00
Amount due on monthly pay rolls, . . . . .	5,600 00
Amount due for police service in Southborough, . . . . .	1,000 00
Reserved on approved monthly estimates for work done (not due until completion of contracts), . . . . .	315,566 34
Balance due city of Boston for taking of Reservoir No. 5, Jan. 4, 1896,* . . . . .	518,975 74
	<hr/>
	\$849,442 08

In addition to the above there are amounts which will be due on various contract sections from the time of each last monthly estimate to Nov. 30, 1896.

## VI. THE WORK ACCOMPLISHED AND IN PROGRESS.

Contracts have been made by the Board for performing substantially all the work which is required to bring the waters flowing in the south branch of the Nashua River from the site of the proposed dam at Clinton to a connection with the Sudbury system, now operated by the city of Boston, and for the distribution of the water among the most of the cities and towns of the Metropolitan Water District.

These contracts are 45 in number, besides the 11 contracts for building the dam at Southborough and Reservoir No. 5, which have been assumed by the Board.

All of these contracts require the completion of the work to be performed under them during the year 1897. In almost all cases the work has been progressing favorably, and in some cases more speedily than was contemplated under the terms of the contracts. In a few instances the work has not been carried on so fast as to be satisfactory to the Board. Such progress, however, has been made, that it is believed, unless some unforeseen exigency shall arise, this

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\* The amount of this balance was paid to the city of Boston in December, 1896.



work will be so far completed that, on or at an early date after Jan. 1, 1898, the additional supply of water to be furnished from the Nashua River will be afforded to the portions of the Metropolitan District which are in urgent need of an increased supply. By the near completion of the dam at Southborough and the preparation of the lower portions of the Reservoir No. 5 a considerable amount of water will be stored in that reservoir during the early winter and spring months of the year 1897, so that in case of urgent need a substantial addition may be made to the existing supply from the Sudbury system.

The estimated value of the work to be performed under the 45 contracts awarded by the Board and of the work remaining to be performed under the 11 contracts made by the city of Boston, when they were assumed by the Board, is \$3,641,717.88. The estimated value of the work performed, subject to the direction of the Board, under all these contracts, to December, 1896, was \$2,029,022.12.

The expenditures of the Board to Dec. 1, 1896, chargeable to administration, have been \$42,712.13; to engineering, \$218,934.01; to construction, \$1,633,911.88; to real estate, damages and diversion of water, \$1,116,208.80; and to the purchase of the water works of the city of Boston, \$601,543.51, — a total of expenditures of \$3,613,310.33. The additional sum of \$518,975.74 was paid to the city of Boston in December, 1896.

The preliminary investigations have so far progressed that it is anticipated that during the coming year contracts will be made for the building of the great dam in Clinton, for the construction of a portion or the whole of the North Dike, for the stripping and preparation of a portion of the lands to be included in the Nashua Reservoir, for the laying of the remaining portions of the main distributing pipe lines in the Metropolitan District and for the construction of pumping engines and stations, and for building a high-service reservoir in the Middlesex Fells. It is also expected that plans will be advanced, if not completed, for the improvement of Spot Pond as a great storage and distributing reservoir.

It is gratifying to be able to state that the extended investigations and the progress of the work have developed no serious obstacles to the entire carrying out of the scheme recommended by the State Board of Health and adopted by the Act of the Legislature of 1895, and that the expenditures made and contracts awarded have not exceeded the estimates then made.

**VII. THE URGENT NEED OF AN ADDITIONAL WATER SUPPLY.**

The continued investigations of the Board have still further confirmed the wisdom of the Legislature of 1895 in urging speedy action for obtaining an additional water supply to meet the increasing demand of the city of Boston and the other municipalities constituting the Metropolitan Water District, and for providing against the contingencies of a season of drought or moderate rainfall. It is certain that the work imposed upon the Board was undertaken none too soon, and that every reasonable effort should be made to hasten the operations which are in progress to secure a safe and ample supply of water.

The report of the chief engineer, explaining in detail the operations of the engineering department, and various explanations and tables, are herewith presented.

Respectfully submitted,

HENRY H. SPRAGUE.  
WILMOT R. EVANS.  
HENRY P. WALCOTT.

Boston, Jan. 1, 1897.

## REPORT OF THE CHIEF ENGINEER.

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*To the Metropolitan Water Board.*

GENTLEMEN :— The following is a report of the operations of the engineering department for the year ending Dec. 31, 1896.

### ORGANIZATION.

On Jan. 4, 1896, it became necessary to increase the engineering force in order to carry on the work of completing the unfinished Reservoir No. 5, in Southborough, which was on that date taken from the city of Boston under the provisions of the metropolitan water act. Upon the taking of this reservoir the Sudbury department was organized, with Mr. Desmond FitzGerald, who had been in charge of this work from its inception, as department engineer, and with nearly all of the engineers previously employed upon this work by the city of Boston, as assistants.

At the beginning of the year Mr. Thomas F. Richardson, engineer of the aqueduct department, not only had charge of the aqueduct, but was temporarily in charge of all work connected with the dam and reservoir to be built upon the Nashua River above Clinton. After the work of constructing the aqueduct was well under way, his duties increased to such an extent that it was thought desirable to organize another department; and on May 21 Mr. Hiram A. Miller, who previously had general charge, under Mr. Richardson, of the surveys for the reservoir, was appointed as engineer of the reservoir department. Mr. Richardson was at the same time given permanent charge of the main dam and was also retained temporarily in charge of the borings and other preliminary investigations for the dikes of the reservoir; his title was also changed to engineer of the dam and aqueduct department.

After making these changes, the engineers reporting directly to the chief engineer were as follows : —

DEXTER BRACKETT, . .	<i>Engineer, Distribution Department.</i>
DESMOND FITZGERALD, .	<i>Engineer, Sudbury Department.</i>
THOMAS F. RICHARDSON, .	<i>Engineer, Dam and Aqueduct Department.</i>
HIRAM A. MILLER, . .	<i>Engineer, Reservoir Department.</i>
REUBEN SHIRREFFS, . .	<i>Principal Office Assistant.</i>
MORRIS KNOWLES, . .	<i>Office Assistant.</i>

Mr. Joseph P. Davis and Mr. A. Fteley have continued to act as consulting engineers.

The engineering force has been increased from time to time during the year, in accordance with the requirements of the work. At the beginning of the year the engineering force numbered 68, and at the end of the year 146. In addition to members of the engineering force who were engaged upon the inspection of the work, other inspectors have been employed to inspect pipe making, pipe laying, masonry and earthwork. The maximum number so employed at any time was 30. Small gangs of men, under the immediate direction of foremen and the general direction of the engineers, have been employed to handle the water pipes received at the pipe yards, to make borings, to repair roads and to do other preliminary and minor work. The maximum number so employed at any time during the year was 97, and the number at the end of the year 74.

#### GENERAL STATEMENT OF THE WORK OF CONSTRUCTION.

In view of the urgent need of an additional water supply in many of the cities and towns in the metropolitan district, it has been the aim to construct as rapidly as practicable, having due regard to economy, those portions of the metropolitan water system which would soonest furnish an additional water supply, and serve to distribute it to the various municipalities. These portions are the aqueduct from the Nashua River to the Sudbury water-shed ; Reservoir No. 5, upon the Sudbury water-shed, already partly constructed by the city of Boston, and the main pipe system in the metropolitan district, leading from Chestnut Hill Reservoir to Spot Pond and to the cities and towns in the district.

The existing aqueducts and other works of the city of Boston have sufficient capacity to carry as much water as is needed by the metropolitan water district at the present time from Reservoir No.

5 to Chestnut Hill Reservoir. Plan No. 1 shows the location of the main features of the metropolitan water system, and the principal existing water works of the city of Boston.

### *Nashua Aqueduct.*

A plan and profile of the location of this aqueduct are shown upon Plan No. 2, and details of the aqueduct are shown on Plan No. 3. It has a total length of twelve miles; the first two miles are a tunnel through rock, the next seven miles a masonry aqueduct, including a bridge across the Assabet River, and the last three miles an open channel, following the course of a brook and extending to the upper end of Reservoir No. 5.

Contracts for this work were made at four different times during the year, as follows:—

### *Nashua Aqueduct Contracts.*

DATE OF CONTRACT.	Description.	Name of Contractor.	Amount.*
Feb. 14, 1896,	Sections 2 and 3, Nashua Aqueduct, 10,308 feet tunnel, 1,011 feet masonry aqueduct.	E. D. Smith & Co., .	\$370,826 00
May 9, 1896,	Sections 4, 5, 6, 7, 9 and 10, Nashua Aqueduct, 35,501 feet masonry aqueduct.	Silvio Casparis, . .	721,580 60
June 16, 1896,	Section 8, Nashua Aqueduct, 359 feet bridge over Assabet River, 30 feet masonry aqueduct.	Jones, Pollard & Co., .	64,676 25
Sept. 22, 1896,	Section 11, Nashua Aqueduct, 15,800 feet open channel with road bridges, and two small dams.	Moulton & O'Mahoney,	89,470 00
			<hr/> \$1,246,552 85

\* These figures are based upon the engineer's estimate of the approximate amount of work of different kinds to be done.

The above contracts provide for the completion of the whole length of the Nashua Aqueduct, with the exception of the very short length next to the Nashua River, which it may not be feasible to construct permanently until the masonry dam across the river is built. It is proposed during the year 1897 to make a temporary connection with the river.

Owing to a somewhat radical change in the design of the aqueduct, which has proved in practice to be very satisfactory, its careful location and the very low prices at which the contracts were

made, this work will be completed for much less than the amount of the original estimate.

*Tunnel.* — The progress on the tunnel has been very satisfactory indeed, as the total amount of tunnel excavated to December 26, measuring to the ends of the headings, was 6,170 feet, or 60 per cent. of the whole length of the tunnel. The length remaining to be excavated is 4,138 feet, which equals the length excavated in the fourteen weeks ending December 26.

A portion of the tunnel will require a masonry lining to support the roof, and none of this lining has as yet been built, although preparations are being made to begin the work.

*Masonry Aqueduct.* — The progress upon the masonry aqueduct has been much less satisfactory than upon the tunnel. The work was let later in the season, and the time consumed in perfecting the organization was such that the work was not fully organized until the autumn, when it was soon necessary to shut down, on account of the cold weather.

The completed aqueduct has a length of about 1 mile, the lower part of the masonry has been built for an additional length of 1,293 feet, making a total of 6,498 feet, or 18 per cent. of the total length to be constructed. The actual progress of the work is considerably greater than indicated by the above percentage, because quite a length of aqueduct trench is practically ready to receive the masonry; many culverts have been built, and, on the whole, by far the most difficult portions of the work have been done. Every endeavor will be made to have this work completed at the end of the next working season.

*Assabet Bridge.* — Although the Assabet bridge was not let until June 16, the contractors have prosecuted the work very energetically, so that the foundations for all of the seven arches have been constructed to a point above the level of the water in the mill pond crossed by the bridge, and the arch stones of three of the arches have been laid. Most of the stones required for the completion of the bridge are on the ground, and there seems to be no reason to doubt that the work will be completed ahead of the contract time.

*Open Channel.* — The open channel was not let until September 22, and the progress since that time has been rather slow. The amount of work to be done is small in comparison with that upon other sections of the aqueduct, and it should be completed without difficulty during the coming year.

*Reservoir No. 5.*

This large reservoir was originally designed by the city of Boston for the storage of the water from a portion of the Sudbury watershed, but it will also be valuable in connection with the metropolitan system of works, particularly in the next few years, before the storage reservoir upon the Nashua River is ready for use.

The construction of this reservoir involves the building of a dam, to retain in the deepest place about 65 feet of water, and the removal of trees, bushes, soil and muck from the area to be flooded with water. The soil and muck removed in the improvement of the reservoir are deposited where the water would otherwise be shallow, and faced with gravel, so that the reservoir will be surrounded with gravelly shores. Where the depth of water would otherwise be less than 8 feet, the reservoir is being excavated to this depth. Plan No. 4 shows the form which this reservoir will have when completed by the filling of the shallower portions, and shows the portions excavated and to be excavated.

The first contracts for the construction of this reservoir were made by the city of Boston, as follows: one large contract for the dam, in 1893, although work upon it was not begun until 1894; three contracts in 1894, one of them for the improvement of the reservoir and two for other work connected with the reservoir and dam; and ten contracts in 1895, seven of which were for the improvement of the reservoir and three for building roads, fences and filter beds.

On Jan. 4, 1896, when the work of constructing this reservoir was transferred to the Metropolitan Water Board, there were in force one large contract for the construction of the dam, eight important contracts for improving the reservoir and two minor contracts. These contracts were assumed by the Metropolitan Water Board, under the provisions of the metropolitan water act.

During the year 1896 the Metropolitan Water Board made eleven additional contracts, nine of which were for improving the reservoir, one for building an arch under and widening the embankment of the New York, New Haven & Hartford Railroad, where it crosses the reservoir, and another for sluice gates for the dam.

The following statement gives the gross amount of the contracts made by the city of Boston and in force at the time the works were taken by the Metropolitan Water Board, the amount of work done upon these contracts before they were taken by the Metropolitan

Water Board, and the total amount of the contracts assumed and made during the year. The figures given are the nearest approximations to the final amount of these contracts which can be made at the present time :—

*Reservoir No. 5 Contracts.*

Total amount of the uncompleted contracts of the city of Boston,	. \$1,051,908 54
Amount of work done on these contracts by the city of Boston,	. 512,000 00
Amount of work remaining to be done by the Commonwealth,	. \$539,908 54
Contracts made by Metropolitan Water Board,	. 800,720 71
<hr/>	
Total amount of contracts made or assumed by Metropolitan Water Board,	. \$1,340,624 25

The progress on the contracts, as a whole, has been very satisfactory. The value of work done upon the contract for Dam No. 5, up to Jan. 4, 1896, was about \$284,000, and the amount done from Jan. 4 to Dec. 15, 1896, was about \$220,000. The work on this dam is nearing completion, and it should be finished within two months after resuming work upon the masonry next spring.

The improvement of the reservoir required the removal of 4,544,000 cubic yards of earth. Prior to Jan. 4, 1896, the city of Boston had removed 761,000 cubic yards; from Jan. 4 to Dec. 1, 1896, the amount removed under the direction of the Metropolitan Water Board was 2,016,000 cubic yards, leaving 1,767,000 cubic yards to be removed. The contracts provide that all of this earth shall be removed before Dec. 1, 1897, and the rapid progress made upon the work this year indicates that the work will be completed on or before the time stated.

Under a requirement of the existing contracts, the improvement of the reservoir has been practically completed up to a level 18 feet below the top of the dam, so that the reservoir can be partially filled in the spring of 1897, thereby furnishing a much-needed addition to the water supply of the city of Boston. It is expected that all of the work connected with the reservoir will be completed during the coming year, so that it may be filled in the winter and spring of 1898.

*Distribution.*

The completion of the Nashua Aqueduct and of Reservoir No. 5 will furnish a sufficient supply of water at Chestnut Hill Reservoir in Boston. From this point the water is to be pumped and con-



vayed through pipes to the cities and towns of the metropolitan water district. It is the aim to construct the pipe systems so that they will be ready for use by the end of 1897; but, on account of the time required to perfect plans for pumps and pumping stations and to construct and erect pumps, it will not be feasible to have any new pumps ready to operate upon the completion of the pipe lines. The surplus pumping capacity of the high-service pumping station of the city of Boston at Chestnut Hill Reservoir can be utilized to pump water for the cities and towns outside of Boston; and as these pumps will connect with Spot Pond, which has a very large capacity for a distributing reservoir, it will be feasible to maintain a supply in this way until additional pumps are ready for use. In carrying out this plan, the completion of one of the lines of 48-inch pipe from Chestnut Hill Reservoir to Spot Pond is a most important factor, and much of the work during the year has been done on this line.

The principal contracts made during the year in connection with the distribution of water may be summarized as follows:—

11 contracts with four pipe foundries for furnishing 42,875 tons of cast-iron water pipe, ranging in diameter from 48 inches to 6 inches; the total amount of these contracts is . . . . .	\$869,424 86
8 contracts for pipe laying, representing a total of 19.7 miles of pipe, varying in diameter from 48 inches to 16 inches; the total amount of these contracts is . . . . .	166,836 33
5 minor contracts, . . . . .	18,279 59
	<hr/>
	\$1,054,540 78

The progress on these contracts has been very satisfactory, as up to the end of the year 1896 the total quantity of pipe inspected and accepted amounted to 38,080 tons, and the amount of pipe laid equalled 15 miles. The amount of pipe now on hand in the pipe yards in Somerville and Edgeworth equals a length of 13.8 miles, and the additional length contracted for, but not yet received at the pipe yards, equals 4.1 miles.

The total length of the 48-inch pipe line now being laid from Chestnut Hill Reservoir to Spot Pond is 11.7 miles, of which 7.56 miles have been laid, and existing contracts cover an additional 1.67 miles, leaving 2.45 miles for which no contracts have yet been made. The pipes across the Charles and Mystic rivers are included in the lengths for which contracts have not yet been made.

It is expected to so far complete the pipe systems during the year 1897 that water can be distributed to the cities and towns in the metropolitan water district in 1898.

*Summary of Contracts to Nov. 30, 1896.*

The contracts made and assumed by the Metropolitan Water Board from Dec. 27, 1895, when the first contract for construction was made, to Nov. 30, 1896, may be summarized as follows : —

PORTION OF WORK.	Number of Contracts.	Amount.
Nashua Aqueduct, . . . . .	10	\$1,246,552 85
Reservoir No. 5, assumed from the city of Boston (uncompleted portions), . . . . .	11	539,903 54
Reservoir No. 5, made by Metropolitan Water Board,	11	800,720 71
Distributing system, . . . . .	24	1,054,540 78
Totals, . . . . .	56	\$3,641,717 88
Value of work done on these contracts to dates of December estimates, . . . . .	. .	\$2,029,022 12

*Force Employed on Works.*

The largest force employed upon the works at any one time during the year was in the latter part of October, 1896, as follows : —

	Men.	Horses.
Contractors' force : —		
Nashua Aqueduct, . . . . .	1,543	215
Dam and Reservoir No. 5, . . . . .	2,040	573
Pipe laying, . . . . .	525	57
	4,108	845
Day labor force, . . . . .	79	
Engineers, . . . . .	156	
Inspectors, not engineers, . . . . .	29	
Totals, . . . . .	4,372	845

A detailed statement of the work done in the different departments of the engineering force is as follows : —

#### RESERVOIR DEPARTMENT.

HIRAM A. MILLER, *Department Engineer.*

In this department is included the greater part of the work to be done in connection with the construction of the reservoir upon the Nashua River above Clinton, exclusive of the dam. The work upon the reservoir was, as already stated, temporarily in charge of Mr. T. F. Richardson, until May 21, when Mr. Hiram A. Miller was appointed in charge of this work, reserving, however, to Mr. Richardson the completion of the borings and other investigations to be used as the basis for locating and designing the dikes. Statements with regard to the dikes will, therefore, be found under the head of the dam and aqueduct department.

The work in this department has been almost wholly of an engineering nature, as the work of construction has not been begun. The force during the greater part of the year has been organized as follows : 1 department engineer ; 4 assistant engineers in charge of field parties, and a small office force under the immediate direction of the chief draftsman of the dam and aqueduct department. The assistant engineers are Charles A. Bowman, Chester W. Smith, Moses J. Look and Harry J. Morrison.

The force employed upon this part of the work has varied from 17, at the beginning of the year, to 25, at the end of the year.

The main office of the department has been located in Pierce's Block, Clinton, and a branch office has been maintained at West Boylston.

#### NASHUA RESERVOIR.

*Descriptive.* — In order that the subsequent statements with regard to the work done on the reservoir may be understood, I will give a brief description and statistics.

The reservoir is to be formed by constructing a masonry dam across a gorge through which the river flows just above Clinton, and by constructing dikes to the north and south of the main dam, to prevent the water from overflowing from the reservoir in other directions.

The reservoir will flood a very large area, containing a railroad, roads, houses, mills and other buildings, and it will be necessary to

build roads to take the place of those flooded, and to provide a new location for the railroad.

In order to improve the quality of the water stored in this reservoir, it is proposed to remove all of the soil and vegetable matter from its site, so that the water will come in contact only with earth which is practically free from organic matter.

*Statistics relating to the Nashua River Reservoir.\**

Area of water surface (acres), . . . . .	4,195
Area of water surface (square miles), . . . . .	6.56
Total contents (gallons), . . . . .	63,068,000,000
Length (miles), . . . . .	8.41
Maximum width (miles), . . . . .	2.05
Total length of shore line, not including the islands (miles), . . . . .	35.40
Maximum depth (feet), . . . . .	129
Average depth (feet), . . . . .	46
Length of railroad flooded (miles), . . . . .	6.56
Length of roads flooded (miles), . . . . .	19.21
Buildings flooded : —	
Mills, . . . . .	6
Churches, . . . . .	4
School-houses, . . . . .	6
Dwellings, . . . . .	224
Inhabitants on land required for reservoir, . . . . .	1,711

*Land Surveys.* — Owing to a provision of the metropolitan water act, that damages shall be paid for injury to lands not taken for the reservoir in West Boylston and portions of Boylston, and to the desirability of determining the boundaries of estates of which a part is to be taken for the reservoir, the area to be surveyed has been very large. Up to December 1 the total area surveyed was 11,523 acres, or about 18 square miles. Of this, 9,301 acres, or about 14½ square miles, have been plotted upon sectional plans 24 inches high and 36 inches wide, to a scale of 100 feet to an inch. Forty of these sectional plans have been completed and tracings of them have been made, and 36 are in progress; about 600 blue-prints of these plans have been made. Thirty-nine of the sectional plans have been reduced to a scale of 300 feet to an inch, and transferred to other sheets. Seven hundred and eleven deeds have been copied and 450 plots of land have been made from the descriptions contained in the

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\* Taken from the report of the Massachusetts State Board of Health upon a metropolitan water supply, February, 1895.

deeds, in order to compare the deeds with the surveys of the ground. One hundred and fifty-three old plans of parcels of real estate have been borrowed, and tracings of them have been made.

*Relocation of Roads.* — Much attention has been given to the question of roads surrounding the reservoir, to take the place of those which will be submerged by filling the reservoir. Careful surveys have been made to determine the topography, to a considerable width, for about 17 miles of road relocation, and estimates of cost have been made on 13 miles of road location. One and one-half miles of located road have been staked out, and profiles of 12½ miles of existing roads have been made.

*Relocation of Central Massachusetts Railroad.* — Surveys for the relocation of the Central Massachusetts Railroad through Oakdale have been made by the engineers of the reservoir department; other surveys for the relocation of this road, through Berlin and Clinton, have been made by the engineers of the dam and aqueduct department, and will be referred to subsequently.

*Removal of Soil.* — In order to determine the depth to which the soil should be removed, so as to leave that remaining nearly free from organic matter, 59 samples taken at different depths from the surface have been sent to Mrs. E. H. Richards, chemist at the Massachusetts Institute of Technology, for analysis; and upon the basis of these analyses, and similar analyses previously made for the State Board of Health, taken in connection with local examinations of the ground made by digging small test holes, the amount of soil to be removed has been determined. Eight hundred and sixty-nine test holes have been dug for this purpose.

By far the greater part of the soil to be removed from this reservoir is to be deposited at the site of the North Dike; but it will be more economical and better to dispose of a portion of it in filling shallow portions of the reservoir at Oakdale and elsewhere, and surveys and estimates have been made for this work.

*Accurate Surveys and Levels.* — As a basis for surveys of the reservoir, 53 triangulation stations, including 4 churches, were accurately located in 1895, and 5 additional stations were located in 1896. Using these triangulation stations as a basis, 21 points have been established in the reservoir as a preliminary to dividing the reservoir into squares 1,000 feet on a side. As a basis for future levels, 46

permanent iron benches, each consisting of an iron rod attached to an iron plate sunk deep in the ground, have been put in place, and the elevation of these benches above Boston city base has been carefully determined.

*Survey of Nashua River.* — A survey of the Nashua River and the mill ponds upon it, together with levels showing the fall of the river, have been made by the engineers of the reservoir department. This survey extends from Oakdale, at the head of the reservoir, to East Pepperell, a distance of  $32\frac{3}{4}$  miles, and was made for the purpose of obtaining exact information with regard to the water power at the mills along the river.

#### DAM AND AQUEDUCT DEPARTMENT.

THOMAS F. RICHARDSON, *Department Engineer.*

The work now in charge of this department includes the borings and other investigations for the dams and dikes of the Nashua Reservoir, the construction of the Nashua Aqueduct, the relocation of the Central Massachusetts Railroad through Berlin and Clinton, and the gaging of the Nashua River.

After the work began along the line of the aqueduct, the organization of the engineering force was as follows: 1 department engineer; 3 engineers in charge of the three divisions of the aqueduct; 1 head draftsman in charge of the draughting office; 1 engineer in charge of river gaging and miscellaneous investigations, and a small cement testing force.

Horace Ropes, Alexander E. Kastl and Charles E. Wells are respectively the engineers of the first, second and third divisions of the aqueduct; Ernest G. Hopson is head draftsman; and David Hinckley is in charge of gagings and investigations.

The inspectors employed to inspect the work of construction were in part engineers and in part masons who had had experience in inspection. The engineering force employed upon this part of the work varied from 17 at the beginning of the year to 39 at the end of the year.

The main office of the department has been located in Pierce's Block, Clinton, and a branch office has been maintained at Northborough for the use of the engineers of the second and third divisions of the aqueduct work.

## NASHUA DAM.

Masonry dam to be founded on solid rock. Length across valley at water level, 1,250 feet; maximum height of water line above surface of ground, 129 feet; above surface of rock, 184 feet; water level, 395 feet above Boston city base.\*

The work of making borings, to determine accurately the form of the surface of the rock and the character of the rock at the location of this dam, was in progress at the beginning of the year, when six gangs were engaged in making pipe borings, that is, in driving pipes through the earth to the rock and washing the material encountered to the surface by water delivered at the bottom of the driven pipe through a smaller wash-pipe, and one gang was engaged in drilling into the rock with a diamond drill. In February a second diamond drill was obtained, in order to expedite the work.

The pipe borings were completed June 24, and the diamond drill borings July 9, 1896. The total number of pipe borings was 806, of which 305 were made in 1895. The aggregate length of these borings was 15,308 feet, or very nearly 3 miles. Thirty-eight diamond drill borings were made, having an aggregate length of 2,489.1 feet, of which 178 feet were drilled in 1895. The maximum depth of any hole was 286.1 feet, and the average depth 65.5 feet.

In order to operate the diamond drills, a pipe was first driven through the earth down to the solid rock, or until stopped by a large boulder, and cleaned out with a jet of water, and the diamond drill was lowered to the rock or boulder through this pipe. The lengths above given for the work of the diamond drill are the lengths actually drilled below the bottom of the driven pipe. The pipes were driven every 20 feet up and down stream and every 10 feet across the deeper portions of the valley; nearer the ends of the dam they were driven 20 feet apart in each direction. They extended both up stream and down stream, beyond the proposed location of the dam, and showed very clearly the form of the surface of the rock and the character of the earth and rock penetrated.

The results of the borings have been submitted to Prof. W. O. Crosby, geologist of the Massachusetts Institute of Technology, who has also made a very careful geological examination of the

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\* Boston city base, which is used as the basis of levels on the metropolitan water works, is approximately at the level of low tide. The base used upon the Boston water works is 10 feet higher.

whole surrounding country. Professor Crosby was consulted upon this matter soon after the borings were started, and we have had the benefit of his advice while making them.

On Oct. 1, 1896, he submitted his final report upon the structure and character of the rock and earth encountered at the location of the dam, a copy of which has already been sent you. In a general way the results found are as follows:—

The north-west slope of the gorge through which the river runs is composed of granite covered with a comparatively thin layer of sand or gravel. The south-east slope is composed of metamorphic slate or schist, covered above the level of the mill pond with a layer of earth about 30 feet in thickness and beneath the mill pond with a greater thickness. Above the level of the mill pond the covering on the south-east slope is nearly all an unmodified drift of boulder clay or till, while under the mill pond the drift is nearly all modified and largely sand and gravel. The contact between the granite and the schist is an igneous one, the granite having come up in a molten state and being firmly welded to the schist. If the earth were removed, the schist on the south-east side of and under the river would show a nearly regular slope down to the point of contact with the granite, and there would be at the junction of the two an abrupt wall of granite from 30 to 40 feet in height.

The erosion which occurred before the rock was covered with earth seems to have acted to a much greater extent upon the softer schist than upon the harder granite, and in this way to have produced this abrupt wall, and even in some cases an undercutting of the granite. The gorge is a narrow one, as its width 40 feet above the deepest point is only from 90 to 135 feet.

The borings have not only demonstrated that a dam can be safely built at the proposed location, but also furnish all of the information required for determining with exactness the most economical location of the dam, and for specifying with an unusual degree of accuracy the amount and character of the work to be done in preparing its foundations.

Since the completion of the borings the work of preparing the final plans of the dam has been carried on as rapidly as practicable without delaying other work which requires to be completed sooner, and it is expected that they will be ready in time to make contracts for the dam in 1897.



## NORTH DIKE.

In order to obtain the full information required for the locating and designing of this dike it has been found necessary to make a great many deep driven pipe borings, and to make experiments upon the filtration of water through the materials contained in the plain across which the dike is to be built, and through the materials which are to be used in building the dike.

For this purpose three boring gangs began work April 1 and three others August 15, and the work has progressed continuously since the latter date. At the end of November 273 borings, having an aggregate depth of 30,919 feet, had been made. The results confirm those obtained by the investigations of the State Board of Health, as they show that the portion of the plain where the dike is to be located is composed mainly of very fine sand, which is nearly impervious to water. The borings of the easterly section of the dike are approaching completion, but those on the westerly section, which is much less difficult to construct, have not yet been begun.

Professor Crosby has been consulted with regard to the method of conducting and the interpreting of the results obtained from these borings, and has submitted a preliminary report. When the borings are completed he is to submit a final report upon the geological features of the plain and the interpretation of the results of the borings.

For the filtration experiments a rough building, 70 feet long and 25 feet wide, has been built. This contains a water-tight wooden tank, 60 feet long, 6 feet wide and 8 feet deep, and five circular galvanized-iron tanks, 5 feet in height and about 28 inches in diameter. Inside of the large tank a dam of soil 8 feet high has been formed, and the water has been filled in one end of the tank to a depth of about 8 feet, while the other end has been kept drained. The amount of water filtering through the soil has been measured, and the ability of the soil to support the pressure of water under very unfavorable circumstances has been determined. This experiment has been made with soil not consolidated in any way, and again with soil deposited in water. It has been found that the soil is practically water-tight. The smaller tanks have been filled with various materials of which the plain across which the dike is to be constructed is composed, and with soils of various kinds which are to be used in the construction of the dike, and the filtering capacity

of these materials is being determined. These experiments are still in progress.

One other filtration experiment is being made by running water from the town supply upon a filter bed constructed in the plain near the experiment station. The filter bed has an area of  $\frac{1}{10}$  of an acre and a maximum depth of 6 feet. Pipes have been driven down to the level of the ground water in all directions around this filter bed, and the effect of the water run into the ground at this place upon the height of the water in the ground is being noted. This experiment is intended to show, by the rise of the water in the ground in the vicinity of the filter bed, the extent to which water will filter through the material found at the lower depths of this sandy plain.

#### SOUTH DIKE.

This dike differs from the North Dike in that it follows, for the greater part of its length, a ridge nearly or quite at the proposed level of high water in the reservoir, and in this ridge the solid rock is near the surface. In order to determine the exact depth to the rock, steel rods have been driven down to it at 566 places, the aggregate length driven being 3,657 linear feet. In order to determine the depth of the rock where it was too far below the surface to be reached in a satisfactory manner with the steel rods, pipes have been driven in the manner already referred to. The pipe borings were made from April 14 to May 28, and from June 24 until August 15; 67 borings, having an aggregate depth of 1,409 feet, were made.

In order to determine the character of the rock, a diamond drill was used at the South Dike from July 10 to August 14, making 7 borings, aggregating 324.2 feet in depth. The maximum depth of any diamond drill boring was 65.3 feet, and the average depth 46.3 feet. The results obtained from these borings agree substantially with those obtained from the preliminary borings by the State Board of Health, but are much more complete, and furnish all of the information required for the economical and safe location of this dike.

#### RELOCATION OF CENTRAL MASSACHUSETTS RAILROAD.

The construction of the Nashua Reservoir requires the relocation of the Central Massachusetts Railroad for a distance of about  $6\frac{1}{2}$  miles, and for the purpose of determining the best line for this relocation

four lines were surveyed during the investigation made by the State Board of Health.

During the present year one additional line has been surveyed from the Central Massachusetts Railroad at West Berlin to the location of the Worcester, Nashua & Rochester Railroad in Clinton, and estimates of the cost of reconstructing the railroad on this line have been made.

A survey has also been made and estimates begun of another route from West Berlin, following parallel with the present line of the New York, New Haven & Hartford Railroad.

The Central Massachusetts Railroad and the Worcester, Nashua & Rochester Railroad are both operated by the Boston & Maine Railroad.

#### NASHUA AQUEDUCT.

##### *Preliminary Work.*

The work preliminary to the letting of the contracts for the construction of the Nashua Aqueduct, begun and far advanced toward completion in 1895, was continued at the beginning of 1896. The location of the line had been quite definitely determined at the end of 1895, but much work remained to be done in connection with the taking of lands for the aqueduct and in making additional soundings to determine the depth to the rock, and in the open channel the depth of the mud and soil to be excavated; also in making borings to determine the character of the foundation for the Assabet bridge, and the character of the material to be excavated along the line of the open channel. The following soundings and borings were made:—

One hundred and sixty-one steel rod soundings, having an aggregate depth of 1,903 feet, to determine the position of the rock to be encountered in building the lower  $1\frac{1}{2}$  miles of the masonry aqueduct.

One hundred and thirty-two steel rod soundings, having an aggregate depth of 1,782 feet, along the upper two miles of the open channel, and near Sawin's Dam.

Three hundred and ninety-nine soundings, made with a gas pipe pushed down by hand, to determine the depth of mud and soil in Sawin's Mill Pond.

Ten borings, having an aggregate depth of 391 feet, at the site of the Assabet bridge.

Twelve pipe borings, having an aggregate depth of 264 feet, near the lower end of the masonry aqueduct.

Twenty-eight borings, having an aggregate depth of 409 feet, taken every 500 feet along the line of the open channel.

Estimates were made of the approximate quantities of work of various classes to be done in connection with the contracts.

*Sections 2 and 3, — Rock Tunnel.*

Contractor, E. D. Smith & Co.; date of contracts, Feb. 12, 1896; amount of contracts, \$370,826; length of tunnel, 10,308 feet; width where lined with brickwork, 12 feet 2 inches; where unlined, 13 feet 6 inches; height where lined with brickwork, 10 feet 10 inches; where unlined, 11 feet 10 inches; length of aqueduct not in tunnel, 1,011 feet; width, 11 feet 6 inches; height, 10 feet 6 inches.

Owing to the weather and to the delays incidental to organizing a work where a large amount of machinery is required, the contractor did not begin the work of excavating until March 31, 1896, and it was as late as July 27 before work was in progress at all of the four shafts and at the portal.

A side track was put in from the Central Massachusetts Railroad to a point near Shaft No. 4. A very complete plant was provided for excavating the shafts and tunnel, the whole of the machinery, including drills, pumps and hoists, being operated by compressed air. The compressor plant consists of two double Rand duplex compressors, having cylinders 20 by 36 inches, the compressors being rated at about 250 horse-power each. Four boilers, of 100 horse-power each, were set up near the compressors at a point where coal could be unloaded directly into the boiler house.

From the compressors the compressed air is conveyed to shafts Nos. 3, 2 and 1 through wrought-iron pipes 8, 6 and 4 inches in diameter, and to the portal by a pipe 4 inches in diameter. The most distant shaft is about 1.5 miles from the compressors, and the air is furnished to it with but little loss of pressure.

The headquarters of the contractors are at Shaft No. 3, where many buildings have been erected of sufficient capacity to accommodate in all about 300 men. The laborers employed upon the work are mainly negroes. The number of men employed on the tunnel construction during the week ending Dec. 5, 1896, was 392.

The tunnel, as far as excavated, is wholly through rock, and it is expected that it will continue in rock throughout the entire length. For about 600 feet at the upper end of the tunnel, and for nearly all

the distance from Shaft No. 3 to the portal at the lower end, the rocks encountered are sedimentary rocks, mainly metamorphic slates and schists with unstratified beds of slaty quartzite. The remainder of the tunnel is being excavated through igneous rocks, either granite or diorite.

In some portions of the slate, schist and quartzite the rock is soft and seamy and requires timbering to support it during construction, while through the diorite and granite the rock is very hard and self-supporting.

The portions of the tunnel now timbered, and others where the material in the seams is liable to disintegrate and permit the rock to fall, will be lined with brickwork, but none of the lining has as yet been built.

Although the work of excavating under these contracts was begun at a late date, the plant provided was so complete and the work has been so well organized and directed that the progress since the excavation began has been very satisfactory indeed, and at the present rate the excavation of the tunnel will be completed far ahead of the contract time.

The dates of beginning the excavation of different parts of the work are as follows : —

	1896.
Shaft No. 1, . . . . .	June 27.
Tunnel at Shaft No. 1, . . . . .	July 11.
Shaft No. 2, . . . . .	May 5.
Tunnel at Shaft No. 2, . . . . .	June 20.
Shaft No. 3, . . . . .	April 20.
Tunnel at Shaft No. 3, . . . . .	June 27.
Shaft No. 4, . . . . .	March 31.
Tunnel at Shaft No. 4, . . . . .	May 23.
Approach to portal, . . . . .	July 27.
Tunnel at portal, . . . . .	October 10.

In excavating the tunnel, a “heading” is first excavated, which comprises only the upper half of the tunnel, and the lower half, or “bench,” is excavated subsequently.

The distances, in feet, from the shafts or the portal to the “headings” and to the “benches,” Dec. 1, 1896, were as follows : —

	Heading.	Bench.
Shaft No. 1, east, . . . . .	602	519
Shaft No. 2, west, . . . . .	703	655
Shaft No. 2, east, . . . . .	753	678
Shaft No. 3, west, . . . . .	625	538
Shaft No. 3, east, . . . . .	655	592
Shaft No. 4, west, . . . . .	568	534
Shaft No. 4, east, . . . . .	832	759
Portal, west, . . . . .	387	322
Totals, December 1, . . . . .	5,125	4,597
Totals, December 26, . . . . .	6,170	5,799

The lengths, in feet, of uncompleted portions between headings on December 1 were as follows : —

Between Shafts No. 1 and No. 2, . . . . .	1,624
Between Shafts No. 2 and No. 3, . . . . .	1,367
Between Shafts No. 3 and No. 4, . . . . .	1,234
Between Shaft No. 4 and portal, . . . . .	958
Total, December 1, . . . . .	5,183
Total, December 26, . . . . .	4,188

None of the aqueduct not in tunnel on Section 3 has been built, but in making the approach to the portal a portion of the trench in which the aqueduct is to be built has been excavated.

*Sections 4, 5, 6, 7, 9 and 10, — Masonry Aqueduct.*

Contractor, Silvio Casparis; date of contracts, May 9, 1896; amount of contracts, \$721,580.60; length of aqueduct, 35,601 feet; width, 11 feet 6 inches; height, 10 feet 6 inches; inclination of aqueduct, 1 foot in 2,500.

These six contracts include all of the masonry aqueduct except the short portion already mentioned on Section 3 and 30 feet to be built in connection with the Assabet bridge. For the greater part of the distance the aqueduct is being built partly or wholly in excavation; but there are several points where the foundations of the aqueduct are above the level of the ground, and in such cases it is being built on embankments of earth, consolidated by being deposited in three-inch layers and rolled with heavy grooved rollers.

The position of the aqueduct in excavation and on embankments is shown upon Plan No. 3, upon which is also shown cross-sections of the masonry. The section on the left is the ordinary section of the aqueduct in dry earth, having a bottom and side walls of American cement concrete, lined with one course of brick masonry and an arch of Portland cement concrete. The American cement concrete is mixed in the proportion of five parts of stone, two parts of sand and one part of cement; the Portland cement concrete in the proportion of four and one-half parts of stone, two and one-half parts of sand and one part of cement.

The centres upon which the concrete arch is laid are covered with galvanized iron, to which a lubricant is applied just before laying the concrete. There has been no trouble from the concrete adhering to the centres, and the interior of the arch after removing the centres is smooth. The arch is subsequently given a wash of Portland cement, applied with a brush. The section of the aqueduct is a very economical one, and, as far as tested, it has proved to be an unusually strong one.

Where the aqueduct is below the level of the water in the ground, two courses of brick are laid in the invert in addition to the thickness of concrete shown in the ordinary section. In wet places a light platform of boards with a wooden drain in the centre is used to keep the concrete dry until it is set. If the earth in the bottom of the trench will not stand at the slope of the regular section of the bottom of the aqueduct, it is excavated to a less steep slope and the concrete walls are carried deeper, as shown by the dotted lines.

None of the aqueduct has yet been constructed on a rock foundation, but it is proposed in such cases to build the brickwork solidly to the rock, as shown in one of the sections on the right side of Plan No. 3.

At the crossings under railroads, and at other places where an unusual strain will come upon the masonry, the aqueduct section is made stronger.

Sections 4, 5, 6 and 7 of the aqueduct are located most of the way through sloping sandy or gravelly ground, and the excavation for the aqueduct does not reach below the level of the water in the ground. On sections 9 and 10, on the other hand, the water level in the ground is generally above the level of the aqueduct, and for a part of the way quicksands and hard material are encountered,

so that these two sections are far more difficult to construct than the others.

On June 23, 1896, the Board assented to the subletting of sections 5 and 6 to Smith & Burden of Long Island City, New York.

As soon as the contracts were let the contractor began the preparatory work of collecting the required plant, building camps for the men, etc., and in a short time began the excavation of the aqueduct trench on Section 10. There was considerable delay in beginning the work upon the aqueduct masonry.

The dates of beginning excavation and aqueduct masonry upon the different sections are as follows:—

[SECTIONS.	DATE OF BEGINNING.	
	Excavation.	Aqueduct Masonry.
Section 4, . . . . .	June 23, 1896.	Sept. 21, 1896.
Section 5, . . . . .	July 9, 1896.	Aug. 26, 1896.
Section 6, . . . . .	July 2, 1896.	Sept. 30, 1896.
Section 7, . . . . .	June 11, 1896.	July 28, 1896.
Section 9, . . . . .	June 12, 1896.	Sept. 18, 1896.
Section 10, . . . . .	May 25, 1896.	July 29, 1896.

The largest force employed at any time on these sections was during the week ending Oct. 10, 1896, when 1,223 men and 171 horses were on the work.

The progress upon the six sections of the aqueduct has been unsatisfactory, and the value of the work done has been far less than the contract requirements. The contract provides that the value of the work done on Dec. 1, 1896, shall equal two-fifths of the total amount of the contracts, and this sum in the present case amounts to about \$289,000; the value of the work done to December 1 was \$167,000, leaving a deficiency in the value of work done of \$122,000. This statement does not fairly represent the progress of the work toward completion, as the work already done has been, to a large extent, earthwork, which requires much more labor on the ground for a given amount of money than masonry, of which the value is largely in the materials prepared elsewhere and brought upon the ground. The more difficult portions of the work have been far advanced, the work on Section 10, the most difficult of all,



having progressed beyond the contract requirements. At the end of the season the work was well organized, and it was advancing quite rapidly.

The following is a tabulation showing the number of linear feet of masonry built and to be built on the several sections : —

SECTIONS.	FOUNDATION AND SIDE WALLS.		ARCH.	
	Built.	To be Built.	Built.	To be Built.
Section 4, . . . . .	457	5,243	431	5,269
Section 5, . . . . .	862	4,438	689	4,611
Section 6, . . . . .	188	6,212	138	6,262
Section 7, . . . . .	770	4,773	737	4,806
Section 9, . . . . .	771	5,497	529	5,739
Section 10, . . . . .	3,450	2,840	2,681	3,609
	6,498	29,003	5,205	30,296

In addition to the aqueduct masonry, 14 masonry culverts are required to carry streams under the aqueduct. Of these, 9 are either built or the work upon them is far advanced, while on the remaining 5 little or no work has been done. At the end of the masonry aqueduct a terminal chamber is to be constructed, and a large part of the excavation for this chamber has been made and much of the stone for it has been delivered.

The greatest difficulty encountered was through the swamp on Section 9, where the bottom of the trench was of quicksand which was very difficult to handle. The work through the quicksand has been practically completed, and it is not expected that any more quicksand will be encountered.

On Section 10 some very hard material was encountered in the excavation at one place, and a difficult railroad crossing has been completed.

#### *Section 8, — Assabet Bridge.*

Contractor, Jones, Pollard & Co.; date of contract, June 16, 1896; amount of contract, \$64,-676.25; length of bridge, 359 feet; length of masonry aqueduct not on bridge, 30 feet; character of structure, 7 granite arches (1 over a road and 6 over a mill pond) supporting an aqueduct; span of arches, 29.5 feet; height of arches above surface of mill pond, 17 feet.

This bridge (see Plan No. 3) crosses a mill pond on the Assabet River. The lower part of the aqueduct upon the bridge has the

same form as the aqueduct at other places, but, for the upper part of the aqueduct upon the bridge, vertical walls covered with iron beams and arches are substituted for the semi-circular arch. Trouble has been occasioned in the case of masonry aqueduct bridges from leaks caused by movements of the masonry due to temperature, and in the present case it has been thought best to dispense with all systems of drainage in the interior of the bridge, and to make the aqueduct absolutely water-tight by inserting a continuous lining of sheet lead back of the 8 inches of brick masonry forming the interior lining of the aqueduct.

In order to construct the bridge it was found necessary either to drain the mill pond or to build the piers under the protection of a coffer-dam. It was found that the cost of the coffer-dam would probably be less than the amount that would have to be paid for drawing down the mill pond, and there were other advantages, so that it was decided to use the coffer-dam.

During the season of 1896 all of the work requiring the protection of the coffer-dam has been completed, as all of the piers are now finished to a point above the level of the water in the mill pond. In addition to this, both abutments have been completed, three of the arches have been turned, and a considerable amount of granite and concrete masonry has been put in place above the level of the springing line of the arches. The centre upon which the arch crossing the road was built has been removed, so that the whole of the space under the arch is available for road purposes. The portions of masonry built are shown in red on Plan No. 3.

The stone for the bridge is obtained from the New England Granite Works of Concord, New Hampshire, and is very satisfactory in quality and appearance. In addition to the stone already laid there is a large quantity at or near the site of the bridge, and there seems to be no reason why this work should not be completed long before the contract time of completion, Nov. 1, 1897.

### *Section 11, — Open Channel.*

Contractor, Moulton & O'Mahoney; date of contract, Sept. 22, 1896; amount of contract, \$89,470; length of section, 15,800 feet.

This section of the aqueduct extends from the lower end of the masonry aqueduct to the head of Reservoir No. 5 of the Sudbury system. It follows the general course of a brook which flows into Reservoir No. 5. The brook meandered through the bottom of the

valley, and at times of high flow spread out over the meadows and swamps which border the brook. Towards its lower end it entered a narrow mill pond, a part of which was very shallow and had a muddy bottom.

The contract provides for the excavation of a channel 20 feet wide on the bottom, with slopes of 3 horizontal to 1 vertical, down to the head of the mill pond. A new dam is to be constructed at the site of the old mill-dam, and the pond is to be retained. The mud and soil under the pond are to be removed, and it is to be deepened.

In order to avoid the necessity of protecting the sides of the channel with riprap, a second dam is to be built across it at a point midway of its length, and the channel is to be made of such depth that the two dams will retain a minimum depth of from 5 to 6 feet of water in the channel. As a result, the current will not be strong enough to move the coarse sand and gravel with which the inner slopes of the channel are to be lined, even when the area of the water section is diminished by the formation of ice at the surface.

The dams are to be constructed of masonry, and to have spillways about 140 feet long, so that there will be little fluctuation of the height of the water in the pond or channel.

Four public ways and two or three private ways crossing the channel are to be maintained, and it is proposed to construct stone arch bridges for this purpose.

The work upon this section was begun too late in the season for the construction of any masonry in 1896. The contractor began the excavation at the site of the mill pond October 3, and later began excavating the channel a mile or more up from the lower end with a steam shovel. At the end of the year the work was progressing much more rapidly than before, and, as the work is not of great magnitude, it should be easily finished during the coming year.

#### SUDBURY DEPARTMENT.

DESMOND FITZGERALD, *Department Engineer.*

The work in charge of this department at the present time is the construction of Dam and Reservoir No. 5, and an additional line of 48-inch pipes from Dam No. 3 to Dam No. 1.

On January 4, when this work was taken from the city of Boston, the engineering force appointed by the Metropolitan Water Board consisted of nearly all of the engineers previously employed by the

city of Boston upon this work, and numbered 25. At the end of the year the engineering force was organized as follows: 1 department engineer; 1 principal assistant engineer; 1 division engineer; 9 assistant engineers in charge of various sections of the work; 1 draftsman.

William C. Hall is principal assistant engineer, Edward S. Larned division engineer, Ellery C. Appleton, Frank A. Bayley, Benjamin F. Goodnough, Oscar S. Heyer, Almon A. Platts, Daniel W. Cole, William Smiddy, Walter W. Patch, Bertram H. Davis, assistant engineers in charge of various sections of the work, and Fred F. Moore draftsman.

Each of the assistant engineers has a small party and is in direct charge of the work in progress under one or more contracts. The total number engaged upon the engineering force at the end of the year was 39.

In addition to the inspectors of work, a physician was employed as sanitary inspector, and he has an assistant.

The office of the department engineer is at 3 Mt. Vernon Street, Boston, and the main office of the department at the works is at Fayville, near the dam. Several branch offices were provided at different points around the reservoir as headquarters for the different assistant engineers.

#### DAM No. 5.

Contractor, Moulton & O'Mahoney; date of contract, July 27, 1893; approximate amount of contract, \$537,000; masonry spillway, 300 feet long, and gate house founded upon solid rock in the deepest part of the valley; the remainder of the dam, earth embankment with concrete core wall extending to the rock; length across valley at water line, 1,865 feet; maximum height of water line above surface of ground, 65 feet; above surface of rock, 70 feet; water level, 260 feet above Boston city base.

Cross-sections of the spillway of the dam and of the earth embankment and core wall may be seen upon Plan No. 4.

This work, when it was taken from the city of Boston, was rather more than half done. About the middle of April the dam was stripped of its winter covering, and work upon it was resumed. The work upon the masonry was prosecuted diligently up to the middle of November, at which time the spillway was completed to within a few feet of the top, and the substructure of the gate house was nearly finished. The large embankments containing the core walls have been carried nearly to grade, but there is still considerable work to be done in placing the coating of soil on the downstream side of the dam and in paving the upper slope.

The largest force employed upon this work at any time during the year was in July, when 436 men and 126 horses were at work upon it.

#### IMPROVEMENT OF RESERVOIR No. 5.

*Descriptive.* — For the purpose of improving the quality of the water stored in this reservoir, the soil and other material containing organic matter is being removed from its site, and in places where the depth below high-water mark is less than 8 feet it is excavated to this depth. In order to diminish the cost of the work, and to furnish a place for depositing the material removed from the reservoir, the excavated material is deposited in what would otherwise be the shallow portions of the reservoir, which diminishes very largely the area from which the soil has to be stripped and the amount of the shallow flowage excavation.

Plan No. 4 shows by full lines the edge of the finished reservoir and by the dotted lines the outer limits of the filling. A typical section is also given on the same plan, to show the method of improving the reservoir.

The embankments of soil and muck are faced on the water side with a layer of coarse gravel, so that the whole of the bottom and sides of the reservoir, with the exception of a very small area at one point, where the mud has excessive depth, will be sand, gravel or other material practically free from organic matter.

*Contracts for improving the Reservoir.* — For the purpose of making contracts, the reservoir is divided into seventeen sections, lettered from A to Q. Contracts for sections A to H inclusive were made by the city of Boston, and assumed on Jan. 4, 1896, by the Metropolitan Water Board. Those for sections I to Q inclusive were made by the Metropolitan Water Board. The locations of the sections are shown on Plan No. 4.

In some cases they include the work of raising and riprapping the slopes of roads which would otherwise have been submerged, and of constructing culverts through the roads. On the branch of the reservoir through which the water of the Nashua River is to flow, the culverts are of large size.

Bids were received for sections I to Q inclusive on April 21, and the contracts were executed on April 27 for all sections except K. In this case there were two bidders for doing the work at the smallest sum bid, which was \$56,240. On this account, and because the

price appeared high, the section was re-advertised, and bids were received on May 7 for doing the work for \$45,600, or \$10,640 lower than the lowest bid at the first letting.

The following table shows the progress of the earth excavation for the improvement of the reservoir up to Dec. 1, 1896. The portions of the reservoir excavated and not excavated are shown upon Plan No. 4.

*Progress of Earthwork, Improvement of Reservoir No. 5, to Dec. 1, 1896.*

CONTRACTOR.	Sections.	Total to be moved.	Moved by Boston prior to Jan. 4, 1896.	Moved by Metropolitan Water Board, Jan. 4, 1896, to Dec. 1, 1896.	Total moved to Dec. 1, 1896.	Remaining to be moved Dec. 1, 1896.
		Cu. Yards.	Cu. Yards.	Cu. Yards.	Cu. Yards.	Cu. Yards.
Auguste Saucier, . . .	A	245,000	121,707	4,037	125,744	119,256
Moulton & O'Mahoney, . .	B	215,000	59,644	145,356	205,000	10,000
Malone & Strang, . . .	C	354,000	91,631	230,369	322,000	32,000
Auguste Saucier, . . .	D	257,000	136,043	117,957	254,000	3,000
Charles Linehan, . . .	E	230,000	106,125	118,875	225,000	5,000
Newell & Snowling, . . .	F	196,000	113,122	80,878	194,000	2,000
Charles Linehan, . . .	G	151,000	81,214	68,786	150,000	1,000
Moulton & O'Mahoney, . .	H	181,000	51,698	118,302	170,000	11,000
Harry P. Nawn, . . .	I	247,000	-	169,800	169,800	77,200
Moulton & O'Mahoney, . .	J	168,000	-	152,400	152,400	15,600
Blagen & Bush, . . .	K	152,000	-	91,900	91,900	60,100
Moulton & O'Mahoney, . .	L	295,000	-	126,300	126,300	168,700
Harry P. Nawn, . . .	M	365,000	-	90,000	90,000	275,000
Thos. Nevins & Sons, . . .	N	145,000	-	130,200	130,200	14,800
Washburn & Washburn, . .	O	550,000	-	85,000	85,000	465,000
Harry P. Nawn, . . .	P	293,000	-	143,000	143,000	150,000
Washburn & Washburn, . .	Q	500,000	-	143,000	143,000	357,000
		4,544,000	761,184	2,016,160	2,777,344	1,766,656

It will be seen by reference to the table that on the whole excellent progress has been made. The work upon the older contracts was nearly finished, except upon Section A, where scarcely any work was done during the year, because certain negotiations for the settlement of land damages were not completed until too late in the season. The newer contracts provided for the completion of the work Dec. 1, 1897, and 42 per cent. of the work was done between the date of letting the contracts (April 27, 1896) and Dec. 1, 1896, which is a very satisfactory progress.

The percentage of the work done by the different contractors is as follows :—

Harry P. Nawn, sections I, M and P, . . . .	45 per cent.
Moulton & O'Mahoney, sections J and L, . . . .	60 per cent.
Blagen & Bush, Section K, . . . .	60 per cent.
Thomas Nevins & Sons, Section N, . . . .	90 per cent.
Washburn & Washburn, sections O and Q, . . . .	22 per cent.

It will be noticed that the slowest progress has been made by Washburn & Washburn, and this is owing in part to the nature of the excavation upon sections O and Q, much of which has a depth of ten feet in very soft material. Owing to the difficulties encountered in the excavation of this material, the contractor has been given permission to excavate and convey the material by the use of a pumping dredge and pipes leading to the dumping areas. The scow and machinery are now building. It is hoped that the contractor will be able to handle the material very rapidly after getting the new plant in operation. A part of the same deep excavation is included in Section M, and scarcely any of the work upon it has as yet been done. The method of handling the material on this section has not been fully determined.

#### NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

On Aug. 6, 1896, an agreement was made with the New York, New Haven & Hartford Railroad by which the Metropolitan Water Board was allowed to construct a new stone arch bridge through the railroad embankment, for conveying the water, and was required to widen the embankment of the railroad and riprap the slopes. Arrangements were made with the railroad company for constructing a temporary bridge of about 100 feet span, to support the tracks while the work of building the stone arch was in progress.

The contract for the stone arch and for widening the railroad embankment was made with Holbrook, Cabot & Daly, Aug. 17, 1896, and they prosecuted the work very energetically, and completed it in a very satisfactory manner early in December, the total cost of the work done by them being \$33,400.21.

#### ROADS.

The construction of Reservoir No. 5 necessitated the abandonment of several miles of roads and the construction of new ones.

Contracts for very nearly all of this work had been made by the city of Boston, but in order to resurface the roads and make some changes which were thought desirable, a small day labor force was started on the work May 26, and the roads were resurfaced and put in good order by the beginning of the autumn.

In compliance with an urgent request from the authorities of the town of Southborough, the road which crosses the reservoir north of and parallel with the railroad was made 10 feet wider than originally intended. This work was done by the contractor for Section D at the contract price for excavation.

#### SANITARY INSPECTION.

In the construction of other reservoirs connected with the water supply of the city of Boston it had been found that where a large number of laborers are gathered in "camps" there is danger of epidemics of diseases, as, for instance, typhoid fever. Arrangements were therefore made for a system of sanitary inspection to cover the entire work of the Metropolitan Water Board within the Sudbury water-shed, and C. P. Jones, M.D., of Southborough, was appointed as sanitary inspector, and given an assistant. Regulations were made with regard to the construction, use and disinfection of latrines, and with regard to other matters which are necessary to prevent the water supply of the city of Boston from becoming polluted. The results during the year have been very satisfactory, as there has been very little sickness and no epidemics, and the streams have been well protected from pollution.

#### AMOUNT OF WORK DONE.

The quantity of contract work done in this department during the year to December 1 is approximately as follows : —

Earth excavation, . . . . .	2,200,000 cubic yards.
Riprap, . . . . .	24,300 cubic yards.
Rubble-stone masonry, . . . . .	8,724 cubic yards.
Concrete masonry, . . . . .	8,648 cubic yards.
Plastering, . . . . .	5,809 cubic yards.
Ashlar, . . . . .	2,533 cubic yards.
Split-stone masonry, . . . . .	567 cubic yards.
Paving, . . . . .	282 cubic yards.
Stone wall, . . . . .	443 rods.



### ENGINEERING.

The work of the engineering department has related mainly to the construction of the reservoir, but surveys have also been made with reference to locating the 48-inch pipe line from Dam No. 3 to Dam No. 1.

### DISTRIBUTION DEPARTMENT.

DEXTER BRACKETT, *Department Engineer.*

The work in charge of this department comprises the pipes, pumping stations, distributing reservoirs and other works in the metropolitan district.

The force is organized as follows: 1 department engineer; 3 assistant engineers in charge of parties engaged on surveys and construction, and an office force, under the charge of 3 engineers reporting directly to the department engineer, engaged upon designing, investigations, and the work connected with the making and delivery of cast-iron pipes.

William E. Foss, John L. Howard and Caleb M. Saville are assistant engineers, in charge of surveys and construction; William B. Fuller office assistant, in charge of miscellaneous designs and investigations; Alfred O. Doane special assistant to department engineer, engaged in organizing and supervising pipe yards and upon designing and inspecting; and Alfred D. Flinn office assistant, engaged upon pipe accounts and designs of pipes, special castings and valves.

The total engineering force employed in this department at the beginning of the year was 18, and at the end of the year 27.

### GENERAL PLAN OF DISTRIBUTING SYSTEM.

The water supplied by the Metropolitan Water Board will for a time come wholly through the present aqueducts of the city of Boston to Chestnut Hill Reservoir, from which water is now supplied by gravity to the lower portions of Boston, and by pumping to the higher portions. There is at present a high-service pumping station at the reservoir.

Plan No. 5 shows the boundaries of the present metropolitan water district, the location of pipes and pumping stations, and the progress of the work of pipe laying to Dec. 1, 1896.

In order to supply the communities north of the Charles River, the water is to be pumped at Chestnut Hill Reservoir through two

lines of 48-inch cast-iron pipes to them, and to Spot Pond which will be used as a distributing reservoir. These are the main pipes of the low-service system, but a branch pipe, 48 inches and 42 inches in diameter, is to be laid from Malden to supply Everett, Chelsea and East Boston, and, to some extent, Charlestown and the northerly portions of Boston proper.

The water is maintained in Chestnut Hill Reservoir at an elevation of 134 feet above Boston city base, and Spot Pond, when full, is at an elevation of 154 feet, or 20 feet higher than Chestnut Hill Reservoir. These low-service pipe lines, and those already leading to the city of Boston, will supply water to all of the lower portions of the metropolitan water district, and to by far the larger part of the population in the district. In order to supply the water to the higher portions, there are to be two additional systems, shown in blue upon Plan No. 5, one the southern high-service system, which is to be an extension of the present high-service system of the city of Boston, and the other the northern high-service system, which is wholly new. In addition to these principal systems there is to be a small system for supplying some very high lands at the extreme southern end of the metropolitan water district. This system is indicated upon the plan by two parallel dotted red lines.

#### PIPES.

It was decided in 1895 that cast iron should be used as the material for the pipes of the distributing system.

The pipes required are, to a large extent, from 48 inches to 36 inches in diameter, and, as there were but four pipe foundries fitted for making pipes of these sizes and so located that they could deliver the pipe economically in Boston, it was thought there might be delays in getting the pipes. When the first contract was made, Dec. 27, 1895, although the pipes were let to the lowest bidder, a somewhat higher price was paid for a contract for 12,500 tons than it would have been necessary to pay for half of this amount. It was thought best, however, to incur the additional expense, in order to insure practically a year's output from one of the largest of the foundries.

The financial depression of the year 1896 was very favorable to this part of the work, as the cities and towns usually requiring these large-sized pipes purchased very few, and, as a consequence, the other three foundries furnished pipes for these works upon very favorable terms.

In all, eleven contracts have been made with the four foundries for furnishing 42,875 tons of pipe, and 45 tons have been ordered without a contract, making a total of 42,920 tons.

These contracts provide for practically all of the pipes which are to be laid north of the Charles River, and for the pipe lines from Chestnut Hill Reservoir to the Charles River, and they represent by far the greater part of the pipe required for the whole metropolitan water district.

Every pipe made has been subjected to careful inspection by inspectors stationed at the foundries, and tests to determine the transverse breaking strength of the iron are made daily.

Yards for the storage of the pipes were established in Somerville near the Union Square station on the Fitchburg Railroad, and in Malden at the Edgeworth station on the Boston & Maine Railroad, at both of which points very good facilities were obtained for storing the pipes. Late in the year, in order to be able to store additional pipes for use during 1897, a third yard was established in Somerville, adjoining the Somerville station on the Fitchburg Railroad.

A very large part of the pipes contracted for has already been delivered, and it is expected that all will be delivered in the early spring, making a total of about 23,260 tons of pipe ready to be laid as soon as the frost is out of the ground.

The following list gives the number of tons of pipes and of special castings called for by the contracts made to Nov. 30, 1896, and by an order for 45 tons of pipes for which no contract was made:—

32,220 tons of 48 inch pipes.				
2,350	"	"	42	"
1,700	"	"	36	"
1,450	"	"	30	"
520	"	"	24	"
2,470	"	"	20	"
1,230	"	"	16	"
130	"	"	12	"
20	"	"	10	"
35	"	"	8	"
30	"	"	6	"
5	"	"	4	"

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Total, 42,160 tons.

760 tons of special castings.

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Total, 42,920 tons.

### VALVES AND OTHER IRON WORK.

Special designs were made for valves to be placed on the lines of the pipes, the sizes varying from 12 inches to 36 inches; for cast-iron frames and covers for blow-off and air-valve chambers, and for beams and plates to be used for covering the larger chambers used for the 30-inch and 36-inch valves.

Two contracts for making valves were made with J. H. Long; one on March 27, 1896, for furnishing 20 36-inch valves, and the other on June 1, 1896, for furnishing 52 valves of sizes varying from 12 inches to 24 inches. The work on these contracts has been delayed for various reasons, and but 15 valves have thus far been delivered.

A contract was made with the Chelmsford Foundry Company, under which it has furnished 125 sets of cast-iron frames and covers, at a cost of \$733.59.

A contract was made with the New Jersey Steel and Iron Company, under which it has furnished 25 sets of steel beams and plates, at a cost of \$1,041.

### PIPE LAYING, LOW-SERVICE PIPE LINES.

It has been the aim to advance as rapidly as possible the construction of one of the two lines of 48-inch pipes leading from Chestnut Hill Reservoir to Spot Pond, and the line chosen is one passing through Brookline, a narrow portion of Boston, Cambridge, Somerville, Medford, Malden, Melrose and the easterly portion of Stoneham to Spot Pond.

This pipe in its course crosses Charles River, from Boston to Cambridge, a short distance above the Cottage Farm station of the Boston & Albany Railroad, and Mystic River, from Somerville to Medford, just below the Middlesex Avenue bridge. At the river crossings, instead of laying one 48-inch pipe it is proposed to lay two 36-inch pipes.

Nearly the whole length of this pipe in the public streets has been laid, or is included in existing contracts for laying pipes. The parts remaining to be done are the river crossings, for which contracts are being prepared, and comparatively short portions not in the public streets. At the Washington Street crossing of the Boston & Maine Railroad in Malden the work has not been begun, on account of a proposed reconstruction of the bridge over the railroad.

The only work done upon the second and more westerly line to Spot Pond is in Beacon Street, Brookline, where the two lines are laid side by side, and in Boylston Street, Cambridge, where it was desirable to lay 2,041 feet of pipe while the widening of the street was in progress. No work has been done on the branch to Everett and Chelsea, but this branch is not as essential as other parts of the work, as there are already pipes leading to these places.

#### CONTRACTS, LOW-SERVICE PIPE LINES.

The following statements give in detail the work done upon the several contracts for laying the low-service lines of 48-inch pipes.\*

##### *Section 2, — Curnan & Hochstadter, Contractors.*

This section includes two lines of 48-inch pipes in Beacon Street, between Chestnut Hill Avenue in Brighton and Winchester Street in Brookline, and a single line of 48-inch pipes in Beacon and St. Paul streets in Brookline, and across private property in Boston, to a point near the Boston & Albany Railroad, a total length of about 20,000 feet. The work was begun May 11 and completed Oct. 3, 1896.

The conditions for doing work on this section were very favorable, as the trenches required but little bracing and the streets were wide, giving sufficient room for the disposal of material, and but few obstructions were encountered. The contractors prosecuted their work energetically, and executed it in a very satisfactory manner. At three points, where the pipes cross over or under equally large pipes of the Boston water works, brick piers and iron beams were provided to support the upper pipes.

##### *Sections 4 and 11, — Snyder & Williams, Contractors.*

Section 4 is a portion of the easterly line of 48-inch pipes leading from Chestnut Hill Reservoir to Spot Pond, and extends from a point near the Charles River in Cambridge, through Cambridge park land, Magazine Street, Massachusetts Avenue and Norfolk Street in Cambridge, and Webster Avenue, Union Square, Bow and Walnut streets in Somerville, to Broadway, a distance of about 16,104 feet.

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\* See also table on page 69.

Section 11 is on the westerly line of pipes, and the portion included in this contract extends from a point near the Charles River, through Boylston Street and Harvard Square to Massachusetts Avenue, a distance of 2,041 feet, making the total length of pipe to be laid under this contract 18,145 feet.

Work was begun on Section 11 on August 17. The material underlying the pipe on Boylston Street, from the beginning of the section near the river to Eliot Street, a distance of 850 feet, was found to be mud, requiring a pile foundation for the pipes. Piles were driven in bents of 2, and capped with 12-inch by 12-inch spruce timber. The bents were spaced about 6 feet apart, giving 4 piles under each length of 48-inch pipe. About 320 linear feet of the pipe on Section 4, near the foot of Magazine Street, were supported in the same manner.

The sewers in some portions of Cambridge and Somerville are so near the surface of the street that the pipes could not be laid without cutting off the drains connecting the houses on one side of the street with the sewer. In such cases it was found necessary to build an additional sewer, and the contractors have for this purpose laid 3,475 feet of sewer pipe, of sizes from 8 inches to 15 inches in diameter, and reconnected several house drains.

The streets on Section 4 are rather narrow, and are well filled with gas and water pipes, sewers, etc. In laying 9,593 feet of pipe on Section 4 it was found necessary to raise or lower 20 main pipes and 108 service pipes of the Cambridge water works, 14 main pipes and 31 service pipes of the gas company, and 31 house or surface water drains connecting with the sewers, also to relay in a new location 2,882 linear feet of main gas pipe.

The contract provided for the completion of this work December 1, but there still remain to be laid 6,511 feet of pipe in Somerville.

Where the 48-inch pipe crosses the Boston & Lowell Railroad at Walnut Street, Somerville, it is to be supported by a plate-girder bridge, a contract for which was made with the Boston Bridge Works on Oct. 3, 1896, and the bridge was to have been completed on December 1, but, as the works of the contractor were destroyed by fire, the bridge has not yet been furnished. As the pipe laying has not yet reached this point, it has not been affected by the delay in completing the bridge.

*Section 6, — Dennis F. O'Connell, Contractor.*

The part of this section included in the contract extends from a point just north of the Mystic River in Medford, through Middlesex Avenue in Medford and Highland Avenue and Medford Street in Malden, to Pearl Street, a distance of 6,800 feet. The work was begun September 2 and completed November 24. Piles were driven to support the pipe for a distance of about 350 feet. No serious difficulties were encountered in doing this work, although considerable water was found in the trench at some places.

*Section 7, — The C. H. Eglee Company, Contractor.*

Section 7 begins on Washington Street, Malden, at a point near Clifton Street, and extends through Washington Street in Malden and Melrose to the Stoneham town line; thence through Wyoming Street, Ravine Road and the Virginia Wood in Stoneham to Woodland Road. The total length is 11,592 feet. Work was begun June 17, and at the end of the working season the contractor had laid a continuous line of pipe from Woodland Road south-easterly to a point about 200 feet north of the Oak Grove station in Malden, a distance of 9,412 feet.

In addition to the 48-inch pipe line, the contract provided for the laying of 1,500 feet of the 36-inch northern high-service pipe line in the Middlesex Fells Parkway; but, owing to the difficulty in obtaining a right of way in this parkway and to delay in receiving from the foundry the thinner pipes required for this contract, it was modified so that the 36-inch pipe line could be omitted, and the contractor was to lay instead about 1,500 feet of thicker 48-inch pipes in Washington Street in Malden, between Pleasant and Kneeland streets. About 2,180 feet of 48-inch pipe remain to be laid to complete the contract. Between October 19 and November 2 arrangements were made with the contractor to lay about 290 feet of 48-inch pipe on Pleasant and Washington streets, Malden. The last-named work was done at the request of the Malden street commissioner, who desired to repave the street.

**NORTHERN HIGH-SERVICE SYSTEM.**

Water for this system is to be taken from Spot Pond, which, as already stated, is to serve as a distributing reservoir for the low-service system. The location of the pumping station has not yet

been definitely determined, but it will probably be on the easterly side of the pond near the present outlet. From the pumping station a 36-inch force main will convey the water to a distributing reservoir, containing about 40,000,000 gallons, to be located in the higher portion of the Middlesex Fells reservation. From this reservoir the water will be conveyed in a 36-inch pipe through the Fells, the Fells Parkway and Highland Avenue to Pleasant Street in Malden, where the pipe will branch in two directions, the westerly branch leading to Medford and Somerville, to supply the higher portions of those cities, and the easterly branch running through Malden, Everett, Chelsea and Revere to Breed's Island in Boston. Contracts have been made for a large part of the westerly and easterly branches above mentioned.

#### CONTRACTS, NORTHERN HIGH-SERVICE PIPE LINES

##### *Section 14, — Collins & Ham, Contractors.*

This section includes the 30-inch pipe line beginning at the corner of Highland Avenue and Pleasant Street in Malden, and extends easterly and south-easterly, through Pleasant, Main and Cross streets, to the corner of Hancock Street in Malden, a distance of 7,330 feet. The contract was dated Oct. 8, 1896, and the contractor began work October 21, but the progress made has been slow, and but 2,670 feet of the pipe, or about one-third of the total length, has thus far been laid.

There was considerable extra work to be done at the crossing of the Pleasant Street culvert on Spot Pond Brook, and the moving of a main water pipe of the city of Malden, in Pleasant Street, also contributed to delay the work.

##### *Section 15, — J. H. McKnight, Contractor.*

This section begins at the terminus of Section 14 in Hancock Street, Malden, runs thence through Hancock Street to Broadway in Everett, thence through High, Foster, Arlington and Nichols streets in Everett, Nichols Street, Washington Avenue and Fenno Street in Chelsea, and Fenno Street in Revere, to a point opposite the Revere Reservoir on Prospect Hill.

Work was begun June 22, 1896, and all except about 730 feet of pipe, which could not be laid on account of delay in receiving valves and special castings, was completed Sept. 1, 1896. The length of



pipe laid under this contract was 4,192 feet of pipe 24 inches in diameter and 9,013 feet of pipe 20 inches in diameter.

*Section 16, — George Goodhue, Contractor.*

This section is located in Fenno and Beach streets and Winthrop Avenue, Revere, and includes the laying of 10,000 linear feet of 16-inch pipe. Work was begun on October 14, and by the terms of the contract should have been completed on December 1, but there still remain about 860 feet of pipe to be laid.

*Section 18, — Collins & Ham, Contractors.*

Section 18 is a part of the westerly branch of the northern high-service system; it includes a 20-inch pipe, beginning at the corner of Elm Street and Highland Avenue in Malden, and extending through Elm and Pleasant streets in Malden, and Salem Street, Middlesex Fells Parkway, and Valley, Forest and High streets in Medford, to a point 600 feet west of Forest Street and north of the Mystic River; also from the corner of South Street and South Street Court in Medford, south of the Mystic River, through South, Walnut and Summer streets and College Avenue, to a point about 350 feet east of the southern division of the Boston & Maine Railroad. The total length of pipe is about 14,400 feet.

The contract was made on October 8, and work was begun on October 14 on Forest Street in Medford, near Medford Square. The work has been done in Forest, Valley and Salem streets in Medford, where a total length of 4,411 feet of pipe has been laid. The progress on this work has been slow, as about 10,040 feet remain to be laid in 1897.

## Principal Items of Work done on Contracts for Pipe Laying, Dec. 15, 1896.

	Section 2, Curran & Hochstadter.	Sections 4 and 11, Snyder & Williams.	Section 6, D. F. O'Connell.	Sections 7 and 13, the C. H. Eggle Company.	Section 14, Collins & Ham.	Section 15, J. H. McKnight.	Section 16, George Good- hue.	Section 18, Collins & Ham.	Totals.
48-inch pipe laid (feet), . . . .	20,354	11,634	6,666	11,182	-	-	-	-	49,836
30-inch pipe laid (feet), . . . .	-	-	-	-	2,670	-	-	-	2,670
24-inch pipe laid (feet), . . . .	-	12	-	-	-	4,192	-	-	4,204
20-inch pipe laid (feet), . . . .	-	-	-	-	-	9,013	-	4,411	13,424
16-inch pipe laid (feet), . . . .	-	-	-	-	-	-	9,138	-	9,138
Rock excavation (cubic yards), . .	1,212.0	-	0.8	1,304.6	-	68.5	6.1	47.6	2,639.6
Earth below grade (cubic yards), .	453.0	264.0	183.7	196.8	36.9	50.9	55.1	7.13	1,246.5
Valve chambers built, . . . .	9	8	5	4	1	5	8	4	44
Concrete masonry (cubic yards), .	50.0	96.0	12.1	-	4.7	-	-	0.5	163.3
Piles driven, . . . .	-	394	120	-	-	-	-	-	514
8-inch sewer pipe laid (feet), . .	-	1,086	-	-	-	-	-	-	1,086
10-inch sewer pipe laid (feet), . .	-	1,207	-	-	-	-	-	-	1,207
12-inch sewer pipe laid (feet), . .	144	1,150	-	-	-	-	-	-	1,294
15-inch sewer pipe laid (feet), . .	-	33	-	-	-	-	-	-	33
Sewer man-holes built, . . . .	2	18	-	-	-	-	-	-	20
Value of work done Dec. 15, 1896, .	\$39,775 26	\$32,360 21	\$16,685 41	\$23,456 49*	\$4,951 67	\$10,575 66	\$4,492 82	\$3,487 11	\$140,784 63

\* Includes the cost of laying 290 linear feet of 48-inch pipe by day labor.

### SOUTHERN HIGH-SERVICE SYSTEM.

The southern high-service system is to be, as already stated, an extension of the present high-service system of the city of Boston. An additional pumping engine will be required at Chestnut Hill, and the plans of the existing pumping station were made with reference to its enlargement to accommodate one more pumping engine. Much work has been done toward obtaining this engine, which will have sufficient capacity to lift 30,000,000 gallons of water per day.

The pipe lines of the southern high-service system have not been finally determined upon as yet, and cannot well be until it is wholly settled whether the city of Quincy will enter the metropolitan water district. The lines shown upon Plan No. 5 are substantially those shown in the report of the State Board of Health upon a metropolitan water supply; but it is the intention, if Quincy enters the district early in the season, to make the plans definite, and to endeavor to lay the pipes during the coming season. The city of Newton does not require water from the metropolitan works at present, and the best method of supplying Watertown and Belmont has not yet been fully determined.

### ENGINEERING.

Although the work of purchasing and laying pipes has occupied a large part of the time of the engineers of the distribution department, the reservoirs and pumping stations which are to be built have not been neglected, and much of the time of the engineering force has been spent on surveys, plans and estimates of these parts of the work.

During the winter of 1895-96 three engineering parties were engaged for about three weeks upon a survey of Spot Pond, and in making soundings to obtain the depth of water and mud. Contour plans of the pond, on a scale of 40 feet to an inch, have been plotted from these surveys as a basis for further studies of the question of the best method of improving the pond by raising or otherwise. A large number of additional soundings have been made by pushing down rods to obtain the depth of mud, and many pipe borings have been made at the sites of suggested dikes and dams.

Extended surveys, soundings, plans and estimates have been made for the purpose of locating pipe lines through, and a distributing res-

ervoir in the Middlesex Fells reservation, and for preparing these portions of the work to be let to contractors.

Surveys, plans, estimates and reports have been made in relation to the admission of Quincy into the metropolitan water district.

Studies have been made relative to the best location for the low-service pumping station which is to be built at Chestnut Hill Reservoir, and the comparative advantages of different types of pumping machinery have been considered.

For the purpose of obtaining information in relation to the cost of pumping engines, the engineer of the distribution department during the month of October visited most of the principal cities of the United States, and inspected the different types of pumping engines in use.

Plans have been made of the different forms of special castings used in pipe laying, and a schedule has been prepared showing the standard dimensions and weights of all pipes and special castings.

An important part of the work of this department is the accounting for the great quantities of pipe made, from the time they are accepted by the inspector at the foundry until they are laid in the ground under the supervision of the inspector of pipe laying.

#### OFFICE FORCE.

REUBEN SHIRREFFS, *Principal Office Assistant* ; MORRIS KNOWLES, *Office Assistant*.

Mr. Shirreffs is at the head of the designing and drafting force, and has been engaged much of the time upon the design of the Nashua Dam, and structures now building on the line of the Nashua Aqueduct. He has also done much work in the preparation of specifications, contract plans and other work usually done in the drafting department. The principal plans drawn are as follows :—

Completed drawings of the seven-arch stone aqueduct bridge across the Assabet River.

Contract drawings for ten sections of the Nashua Aqueduct.

Completed plans and working drawings of fourteen culverts under the Nashua Aqueduct and of the chamber at the end of the aqueduct.

Plans of changes in location of roads crossing the aqueduct in six places.

Many preliminary studies and plans have been made with reference to details of the Nashua Dam, and the best method of utilizing

the power to be available at the dam. Much time has also been spent upon plans of lands to be taken and other plans of property.

Mr. Knowles has charge of the miscellaneous work of the office, such as the procuring of supplies, the making of blue-prints and the filing of plans and records received from outside offices. He has also had charge of many studies and computations relating to the damages caused by the diversion of water, to the probable assessment of cities and towns in the metropolitan water district, and much similar work.

#### ACCIDENTS.

Serious accidents have occurred at three different times in the aqueduct tunnel, by which five men have been killed and two seriously injured. Two of these accidents were due to a premature explosion and to a fall of rock from the roof. There has been one fatal accident in connection with the construction of the bridge across the Assabet River, — one of the men fell from the coffer-dam into the mill pond and was drowned.

Three other fatal accidents have occurred in connection with the pipe systems, two of which were on Section 7 and one on Section 18, of the pipe laying. In one case, on Section 7, a man was killed by the caving in of the side of the trench, and in the other case a man's skull was fractured by being struck with a crowbar thrown by a slipping derrick leg. On Section 18 a teamster was killed by pipes, which, not being properly secured, rolled from the wagon.

The number of fatalities for the year is, therefore, nine, and the number of serious accidents which did not result fatally, two.

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Appended to this report are tables of contracts, giving the amount of work done and other information, and a table of the rainfall upon the Nashua water-shed for the year 1896.

Respectfully submitted,

FREDERIC P. STEARNS,

*Chief Engineer.*

BOSTON, MASS., Dec. 31, 1896.

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## APPENDIX.

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## APPENDIX

## CONTRACTS MADE AND PENDING

*Contracts made by the City of Boston and assumed by the Metropolitan Water*

	1. WORK.	2. Contractor.	3. Date of Contract.
1	Dam No. 5, Southborough, . . .	Moulton & O'Mahoney, Boston, Mass., .	July 27, 1893,
2	Section A, Reservoir No. 5, . . .	Auguste Saucier, South Framingham, Mass.	Aug. 27, 1894,
3	Section B, Reservoir No. 5, . . .	Moulton & O'Mahoney, Boston, Mass., .	June 12, 1895,
4	Section C, Reservoir No. 5, . . .	Malone & Strang, Boston, Mass., . . .	April 29, 1895,
5	Section D, Reservoir No. 5, . . .	Auguste Saucier, South Framingham, Mass.	June 25, 1895,
6	Section E, Reservoir No. 5, . . .	Charles Linehan, Cambridgeport, Mass.,	April 29, 1895,
7	Section F, Reservoir No. 5, . . .	Newell & Snowling, Uxbridge, Mass., .	April 29, 1895,
8	Section G, Reservoir No. 5, . . .	Charles Linehan, Cambridgeport, Mass.,	April 29, 1895,
9	Section H, Reservoir No. 5, . . .	Moulton & O'Mahoney, Boston, Mass., .	April 29, 1895,
10	Filter beds near Marlborough Junction,†	John Berry, Fayville, Mass., . . .	April 4, 1895,
11	20,000 feet of iron fence along roads, Reservoir No. 5.	Henry Parsons, Marlborough, Mass., .	July 17, 1895,

\* The figures given in this column are the nearest approximations to the final amounts of these contracts which can be made at the present time.

† Contract completed.

## No. 1.

DURING THE YEAR 1896.

*Board Jan. 4, 1896, relating to Reservoir No. 5 of the Sudbury System.*

4. Date for Completion of Contract.	5. Prices of Principal Items.	6. Approximate Amount of Contract.*	7. Value of Work done to Time of December Estimate.	
Nov. 1, 1896,	Earth excavation and disposal in embankment, \$0.24 per cu. yd.; rock excavation, \$1.67 per cu. yd.; concrete masonry, Am. cem. mortar, \$4.70 per cu. yd.; rubble stone masonry in mortar, \$5.50 per cu. yd.; facing stone masonry (range work), \$17.00 per cu. yd.	\$537,000 00	\$504,425 77	1
Dec. 1, 1894,	Earth excavation, \$0.19½ per cu. yd.; split stone masonry in mortar, \$7.00 per cu. yd.; riprap, \$1.20 per cu. yd.	60,000 00	35,046 25	2
Dec. 1, 1896,	Earth excavation, \$0.29 per cu. yd.; split stone masonry, \$9.00 per cu. yd.; riprap, \$1.00 per cu. yd.	76,000 00	73,990 48	3
Dec. 1, 1896,	Earth excavation, \$0.21 per cu. yd.; split stone masonry, \$10.00 per cu. yd.; riprap, \$0.75 per cu. yd.	94,000 00	89,024 02	4
Dec. 1, 1896,	Earth excavation, \$0.21 per cu. yd.; split stone masonry, \$9.00 per cu. yd.; riprap, \$1.20 per cu. yd.	78,000 00	77,255 52	5
Dec. 1, 1896,	Earth excavation, \$0.23 per cu. yd., . . . .	53,000 00	52,636 36	6
Dec. 1, 1896,	Earth excavation, \$0.26 per cu. yd., . . . .	51,000 00	50,698 64	7
Dec. 1, 1896,	Earth excavation, \$0.19 per cu. yd., . . . .	29,000 00	28,383 08	8
Dec. 1, 1896,	Earth excavation, \$0.26 per cu. yd., . . . .	47,000 00	44,649 80	9
Aug., 1895,	Earth excavation, \$0.23½ per cu. yd., . . . .	11,903 54	11,903 54	10
- -	\$0.79½ per lin. ft., . . . .	15,000 00	7,887 28	11
		\$1,051,903 54	\$975,900 74	

NOTE.—The value of the work done on these contracts by the city of Boston amounted to \$512,000, leaving about \$540,000 as the value of the work to be done by the Metropolitan Water Board, and about \$464,000 as the value of the work done by the Metropolitan Water Board during 1896.



## CONTRACTS MADE AND PENDING DUR-

*Contracts made by the Metropolitan Water Board*

[EXPLANATION.—The amounts given in columns 4 and 5 are those determined when canvassing the amounts of the final estimates, those marked *b* are the amounts as determined by recent approximate cases there is work to be done in addition to that included in the canvass of bids, for which the prices are

1. Number of Con- tract.	2.  WORK.	3. Number of Bids.	AMOUNT OF BID.		6.  Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	9	Section I, Reservoir No. 5,	7	\$74,100 00	\$55,455 00†	H. P. Nawn, Boston, Mass.
2	10	Section J, Reservoir No. 5,	7	42,000 00	40,320 00†	Moulton & O'Mahoney, Boston, Mass.
3	11	Section K, Reservoir No. 5,	7	49,210 00	45,600 00†	Blagen & Bush, Port- land, Ore., and Spring- field, Mass.
4	12	Section L, Reservoir No. 5,	10	79,233 50	74,845 50†	Moulton & O'Mahoney, Boston, Mass.
5	13	Section M, Reservoir No. 5,	9	107,875 00	105,850 00†	H. P. Nawn, Boston, Mass.
6	14	Section N, Reservoir No. 5,	8	55,825 00	52,200 00†	Thomas Nevins & Son, Orange, N. J.
7	15	Section O, Reservoir No. 5,	9	151,113 00	136,040 00†	Washburn & Washburn, New York, N. Y.
8	16	Section P, Reservoir No. 5,	10	79,110 00	77,645 00†	H. P. Nawn, Boston, Mass.
9	17	Section Q, Reservoir No. 5,	14	123,690 00†	115,010 00	Washburn & Washburn, New York, N. Y.
10	32*	Stone arch bridge under N. Y., N. H. & H. R.R., near Fayville, and widening railroad embankment.	6	37,762 00	32,956 00†	Holbrook, Cabot & Daly, Brockton, Mass.
11	36	Sluice gates and floor plates at Dam No. 5.	4	4,890 00	4,635 00†	R. D. Wood & Co., Phila- delphia, Pa.
12		Total, . . . . .		. . . . .	. . . . .	. . . . .

*Contracts made by the Metropolitan Water*

13	2	Section 2, Nashua Aque- duct, 4,800 lin. ft. in tun- nel.	19	\$133,388 00	\$122,398 00†	E. D. Smith & Co., Phila- delphia, Pa.
14	3	Section 3, Nashua Aque- duct, 6,617 lin. ft. in tun- nel, 1,000 lin. ft. in open trench.	18	265,082 50	248,428 00†	E. D. Smith & Co., Phila- delphia, Pa.

\* Contract completed.

† Contract based upon this bid. In the case of Contract No. 17 the contract was awarded to the lowest bidder on a combination bid for sections O and Q.

ING THE YEAR 1896 — *Continued.**relating to Reservoir No. 5 of the Sudbury System.*

bids. The amounts given in column 11 are made up in three ways: those marked *a* are the exact estimates, and those marked *c* are the amounts as determined in making the canvass of bids. In some fixed in the contract.]

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items.	11. Approximate Amount of Contract.	12. Value of Work done to Time of December Estimate.	
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.26½ per cu. yd.	\$65,455 00 c	\$47,711 40	1
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.24 per cu. yd.	40,320 00 c	37,498 56	2
May 8, '96,	Dec. 1, '97,	-	Earth excavation, \$0.30 per cu. yd.	45,600 00 c	28,877 40	3
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.24 per cu. yd.	74,845 50 c	33,182 40	4
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.29 per cu. yd.	105,850 00 c	27,245 50	5
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.36 per cu. yd.	52,200 00 c	46,707 84	6
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.23½ per cu. yd.	158,270 00 b	25,408 89	7
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.26½ per cu. yd.	77,645 00 c	42,858 72	8
April 27, '96,	Dec. 1, '97,	-	Earth excavation, \$0.23½ per cu. yd.	142,500 00 b	44,420 67	9
Aug. 17, '96,	Dec. 1, '96,	Dec. 15, '96,	Earth excavation, \$0.30 per cu. yd.; ashlar masonry, \$16.00 per cu. yd.; rubble stone masonry, \$5.00 per cu. yd.; voussoir masonry, \$22.00 per cu. yd.; riprap, \$1.25 per cu. yd.	33,400 21 a	33,400 21	10
Sept. 17, '96,	Dec. 15, '96,	-	-	4,635 00 c	-	11
. . . . .	. . . . .	. . . . .	. . . . .	\$800,720 71	\$367,311 59	12

*Board relating to the Nashua Aqueduct.*

Feb. 14, '96,	Dec. 1, '97,	-	Large shaft excavation, \$40.00 per lin. ft.; small shaft excavation, \$25.00 per lin. ft.; tunnel excavation, \$3.35 per cu. yd.; brick masonry for lining, laid in mortar, 1 part Am. cem. to 1½ parts of sand, \$11.60 per cu. yd.	\$122,398 00 c	\$46,965 00	13
Feb. 14, '96,	Dec. 1, '97,	-	Large shaft excavation, \$40.00 per lin. ft.; earth excavation, \$0.50 per cu. yd.; tunnel excavation, \$3.35 per cu. yd.	248,428 00 c	67,395 00	14

CONTRACTS MADE AND PENDING DUR-  
*Contracts made by the Metropolitan Water*

1. Number of Con- tract.	2.  WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6.  Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	19	Section 4, Nashua Aque- duct, 5,700 lin. ft. ma- sonry aqueduct.	16	\$106,107 50	\$104,733 90*	S. Casparis, Columbus, Ohio.
2	20	Section 5, Nashua Aque- duct, 5,300 lin. ft. ma- sonry aqueduct.	16	97,015 50	95,679 80*	S. Casparis, Columbus, Ohio.
3	21	Section 6, Nashua Aque- duct, 6,400 lin. ft. ma- sonry aqueduct.	16	124,325 50	123,775 90*	S. Casparis, Columbus, Ohio.
4	22	Section 7, Nashua Aque- duct, 5,543 lin. ft. ma- sonry aqueduct.	17	105,855 00*	105,565 00	S. Casparis, Columbus, Ohio.
5	23	Section 8, Nashua Aque- duct, Assabet bridge.	17	64,676 25*	59,897 00	Jones, Pollard & Co., Baltimore, Md.
6	24	Section 9, Nashua Aque- duct, 6,268 lin. ft. ma- sonry aqueduct.	14	146,567 50	144,185 00*	S. Casparis, Columbus, Ohio.
7	25	Section 10, Nashua Aque- duct, 6,290 lin. ft. ma- sonry aqueduct.	13	174,442 00	147,851 00*	S. Casparis, Columbus, Ohio.
8	37	Section 11, Nashua Aque- duct, open channel 15,800 feet in length, with two small masonry dams and several stone arch road bridges.	21	89,470 00*	86,960 00	Moulton & O'Mahoney, Boston, Mass.
9	Total, . . . . .					

\* Contract based upon this bid. In the case of Contract No. 22 the contract was awarded to the lowest bidder on a combination bid for sections 7, 9 and 10.

ING THE YEAR 1896 — *Continued.**Board relating to the Nashua Aqueduct — Concluded.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items.	11. Approximate Amount of Contract.	12. Value of Work done to Time of December Estimate.	
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.25 per cu. yd.; rock excavation, \$1.00 per cu. yd.; brick masonry in Am. cem. mortar, \$11.92 per cu. yd.; Am. cem. concrete, \$3.80 per cu. yd.; Portland cem. concrete, \$5.00 per cu. yd.	\$104,783 90 c	\$16,618 35	1
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.25 per cu. yd.; rock excavation, \$1.00 per cu. yd.; brick masonry in Am. cem. mortar, \$11.92 per cu. yd.; Am. cem. concrete, \$3.80 per cu. yd.; Portland cem. concrete, \$5.00 per cu. yd.	95,679 80 c	16,421 20	2
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.24 per cu. yd.; rock excavation, \$0.90 per cu. yd.; brick masonry in Am. cem. mortar, \$11.92 per cu. yd.; Am. cem. concrete, \$3.80 per cu. yd.; Portland cem. concrete, \$5.00 per cu. yd.	123,775 90 c	14,719 70	3
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.25 per cu. yd.; rock excavation, \$1.25 per cu. yd.; brick masonry in Am. cem. mortar, \$12.00 per cu. yd.; Am. cem. concrete, \$3.80 per cu. yd.; Portland cem. concrete, \$5.00 per cu. yd.	105,855 00 c	22,954 60	4
June 16, '96,	Nov. 1, '97,	-	Ashlar masonry, \$17.68 per cu. yd.; voussoir masonry, \$31.43 per cu. yd.; cut stone masonry, \$27.75 per cu. yd.; Portland cem. concrete, \$6.24 per cu. yd.; Am. cem. concrete, 5 parts stone, 2 parts sand, 1 part cem., \$4.19 per cu. yd.; Am. cem. concrete, 6 parts stone, 3 parts sand, 1 part cem., \$5.95 per cu. yd.	64,676 25 c	26,814 25	5
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.27 per cu. yd.; rock excavation, \$1.25 per cu. yd.; brick masonry, \$12.00 per cu. yd.; Am. cem. concrete, \$3.75 per cu. yd.; Portland cem. concrete, \$4.90 per cu. yd.	144,185 00 c	26,323 85	6
May 9, '96,	Nov. 15, '97,	-	Earth excavation, \$0.27 per cu. yd.; rock excavation, \$1.50 per cu. yd.; brick masonry, \$12.00 per cu. yd.; Am. cem. concrete, \$3.75 per cu. yd.; Portland cem. concrete, \$4.90 per cu. yd.	147,351 00 c	84,726 02	7
Sept. 22, '96,	Dec. 1, '97,	-	Earth excavation, \$0.18 per cu. yd.; Am. cem. concrete, \$5.00 per cu. yd.; split stone masonry and paving laid in mortar, \$18.00 per cu. yd.	89,470 00 c	4,382 58	8
.	.	.	.	\$1,246,552 85	\$327,320 55	9

CONTRACTS MADE AND PENDING DUR-  
*Contracts made by the Metropolitan Water*  
**Water Pipes.**

1. Number of Con- tract.	2.  WORK.	3. Number of Bids.	AMOUNT OF BID.		6.  Contractor.
			4. Next to Low- est.	5. Lowest.	
1	1* 12,000 tons 48-inch cast-iron water pipes; 500 tons special castings.	3	\$298,000 00	\$267,500 00†	R. D. Wood & Co., Philadelphia, Pa.
2	5* 5,550 tons cast-iron water pipes; 5,000 tons 48-inch, 550 tons 36-inch; and 50 tons special castings.	3	Pipe, \$20.00 per ton; special castings, \$45.00 per ton.	Pipe, \$19.90 per ton; special castings, \$45.00 per ton.†	McNeal Pipe & Foundry Co., Burlington, N. J.
3	6* 1,545 tons cast-iron water pipes; 520 tons 24-inch, 900 tons 20-inch, 50 tons 18-inch, 30 tons 12-inch, 20 tons 10-inch, 15 tons 8-inch, 10 tons 6 inch; and 60 tons special castings.	5	Pipe, \$20.00 per ton; special castings, \$45.00 per ton.	Pipe, \$19.90 per ton; special castings, \$45.00 per ton.†	McNeal Pipe & Foundry Co., Burlington, N. J.
4	7* 4,470 tons cast-iron water pipes; 3,870 tons 48-inch, 600 tons 36-inch.	†	†	†	Howard-Harrison Iron Co., Bessemer, Ala.
5	8 4,550 tons cast-iron water pipes; 4,000 tons 48-inch, 550 tons 36-inch.	†	†	†	Warren Foundry & Machine Co., Phillipsburg, N. J.
6	84 3,300 tons cast-iron water pipes; 1,450 tons 30-inch, 1,570 tons 20-inch, 290 tons 16-inch.	4	30-in., \$18.70 per ton; 20 and 16 inch, \$18.90 per ton.	30-in., \$18.40 per ton; 20 and 16 inch, \$18.90 per ton.†	Warren Foundry & Machine Co., Phillipsburg, N. J.
7	35* 150 tons special castings.	3	\$40 00	\$39 50†	R. D. Wood & Co., Philadelphia, Pa.
8	38* 1,000 tons cast-iron water pipes; 900 tons 16-inch, 100 tons 12-inch.	3	\$18.40 per ton.	\$17.85 per ton.†	R. D. Wood & Co., Philadelphia, Pa.
9	43 3,550 tons cast-iron water pipes; 1,200 tons 48-inch, 2,350 tons 42-inch.	4	\$19.90 per ton.	48-in., \$18.75 per ton; 42-inch, \$19.25 per ton.†	Howard-Harrison Iron Co., Bessemer, Ala.
10	44 3,000 tons 48-inch cast-iron water pipes.	5	\$18.75 per ton.	\$18.40 per ton.†	Warren Foundry & Machine Co., Phillipsburg, N. J.
11	45 3,150 tons 48-inch cast-iron water pipes.	†	†	†	McNeal Pipe & Foundry Co., Burlington, N. J.
12	Total for pipes, . . .	. . .	. . .	. . .	. . . . .

\* Contract completed.

† Contract based upon this bid.

ING THE YEAR 1896 — *Continued.**Board relating to the Distributing System.***Water Pipes.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items.	11. Approximate Amount of Contract.	12. Value of Work done to Time of December Estimate.	
Dec. 27, '96,	Dec. 1, '96,	Dec. 28, '96,	Straight pipe, \$21.65 per ton of 2,000 pounds; special castings, \$21.65 per ton of 2,000 pounds, delivered at the pipe yards.	\$274,166 23 a	\$274,166 23	1
Mar. 10, '96,	Dec. 1, '96,	Nov. 7, '96,	Straight pipe, \$19.90 per ton of 2,000 pounds; special castings, \$45.00 per ton of 2,000 pounds, delivered at the pipe yards.	114,389 47 a	114,389 47	2
Mar. 10, '96,	Aug. 1, '96,	Nov. 7, '96,	Straight pipe, \$19.90 per ton of 2,000 pounds; special castings, \$45.00 per ton of 2,000 pounds, delivered at the pipe yards.	34,814 76 a	34,814 76	3
Mar. 17, '96,	Dec. 1, '96,	Dec. 5, '96,	Straight pipe, \$19.90 per ton of 2,000 pounds, delivered at the pipe yards.	88,728 22 a	88,728 22	4
Mar. 23, '96,	Dec. 15, '96,	-	Straight pipe, \$19.90 per ton of 2,000 pounds, delivered at the pipe yards.	90,545 00	85,052 60	5
Aug. 12, '96,	Nov. 15, '96,	-	30-inch pipe, \$18.40 per ton of 2,000 pounds; 20 and 16 inch pipe, \$18.90 per ton of 2,000 pounds, delivered at the pipe yards.	62,074 89 b	61,846 88	6
Aug. 12, '96,	Nov. 15, '96,	Dec. 24, '96,	Special castings, \$39.50 per ton of 2,000 pounds, delivered at the pipe yards.	5,715 95 a	5,715 95	7
Sept. 9, '96,	Dec. 15, '96,	Dec. 23, '96,	Straight pipe, \$17.85 per ton of 2,000 pounds, delivered at the pipe yards.	18,097 84 a	18,097 84	8
Oct. 20, '96,	May 1, '97,	-	48-inch pipe, \$18.75 per ton of 2,000 pounds; 42-inch pipe, \$19.25 per ton of 2,000 pounds, delivered at the pipe yards.	67,787 50 c	-	9
Oct. 22, '96,	May 1, '97,	-	Straight pipe, \$18.40 per ton of 2,000 pounds, delivered at the pipe yards.	55,200 00 c	20,681 60	10
Oct. 20, '96,	May 1, '97,	-	Straight pipe, \$18.40 per ton of 2,000 pounds, delivered at the pipe yards.	57,960 00	22,944 80	11
. . . . .	. . . . .	. . . . .	. . . . .	\$869,424 86	\$726,433 35	12

† No bids were received on these contracts; they were made at the prices fixed by the bids for contracts Nos. 6 and 44.

## CONTRACTS MADE AND PENDING DUR-

*Contracts made by the Metropolitan Water***Pipe Laying.**

1. Number of Con- tract.	2.  WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6.  Contractor.
			4. Next to Low- est.	5. Lowest.	
1	18* Laying 20,000 lin. ft. of 48-inch pipes in Brookline and Brighton (Section 2).	21	\$37,502 25†	\$26,047 50	Curnan & Hochstadter, Poughkeepsie, N. Y.
2	29* Laying 4,400 lin. ft. of 24-inch and 9,700 feet of 20-inch water pipes in Malden, Everett, Chelsea and Revere (Section 15).	5	12,744 00	11,873 00†	J. H. McKnight, Pittsburg, Pa.
3	30 Laying 11,500 lin. ft. of 48-inch and 1,500 feet of 36-inch water pipes in Malden, Melrose and Stoneham (sections 7 and 18); also laying 1,500 feet of 48-inch water pipes under a modification of the contract.	4	27,838 20	27,718 50†	The C. H. Eglee Co., Boston, Mass.
4	31 Laying 18,300 lin. ft. of 48-inch water pipes in Cambridge and Somerville (sections 4 and 11).	6	42,581 90†	42,421 70	Snyder & Williams, Dayton, Ohio.
5	33* Laying 6,800 lin. ft. of 48-inch water pipes in Medford and Malden (Section 6).	5	19,699 00	16,838 00†	Dennis F. O'Connell, Boston, Mass.
6	39 Laying 7,330 lin. ft. of 30-inch cast-iron water pipes in Malden (Section 14).	8	9,095 60	8,208 60†	Collins & Ham, South Boston, Mass.
7	41 Laying 10,000 lin. ft. of 16-inch cast-iron water pipes in Revere (Section 16).	11	5,441 50	4,728 00†	George Goodhue, Concord, N. H.
8	42 Laying 14,400 lin. ft. of 20-inch cast-iron water pipes in Malden and Medford (Section 18).	13	10,357 00	9,798 25†	Collins & Ham, South Boston, Mass.
9	Total for pipe laying, . . . . .	. . . . .	. . . . .	. . . . .	. . . . .

**Miscellaneous.**

10	4	20 36-inch water valves, .	10	\$9,400 00†	\$7,800 00	Josiah H. Long, Boston, Mass.
11	26*	25 sets of steel work for covering valve chambers.	4	1,575 00	1,066 00†	New Jersey Steel & Iron Co., Trenton, N. J.
12	27*	Cast-iron frames and covers.	7	733 26	733 91†	Chelmsford Foundry Co., Boston, Mass.
13	28	52 water valves; 6 24-inch, 6 20-inch, 20 16-inch, 20 12-inch.	3	4,832 00	4,608 00†	Josiah H. Long, Boston, Mass.
14	40	Pipe bridge over Boston & Maine R.R. at Walnut Street, Somerville.	3	2,615 00	2,497 00†	Boston Bridge Works, Boston, Mass.
15		Total miscellaneous, . . . . .	. . . . .	. . . . .	. . . . .	. . . . .
16		Total for Distributing System, . . . . .	. . . . .	. . . . .	. . . . .	. . . . .

\* Contract completed.

† Contract based upon this bid.

ING THE YEAR 1896—*Continued.**Board relating to the Distributing System—Concluded.***Pipe Laying.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items.	11. Approximate Amount of Contract.	12. Value of Work done to Time of December Estimate.	
April 27, '96,	Sept. 1, '96,	Oct. 13, '96,	Laying 48-inch pipe, \$1.73 per lin. ft.; rock excavation, \$1.50 per cu. yd.	\$39,775 26a	\$39,775 26	1
June 11, '96,	Sept. 15, '96,	Nov. 11, '96,	Laying 24-inch pipe, \$0.83 per lin. ft.; laying 20-inch pipe, \$0.73 per lin. ft.	10,575 66a	10,575 66	2
June 10, '96,	Nov. 1, '96,	-	Laying 48-inch pipe, \$1.92 per lin. ft.; rock excavation, \$3.00 per cu. yd.; laying 36-inch pipe, \$1.33 per lin. ft.; laying 48-inch pipe under modification of contract, \$2.42 per lin. ft.	30,000 00b	26,805 16	3
Aug. 6, '96,	Dec. 1, '96,	-	Laying 48-inch pipe, \$1.87 per lin. ft.; driving and capping piles, \$23.00 per bent.	44,600 00b	32,330 21	4
Aug. 27, '96,	Dec. 1, '96,	Dec. 24, '96,	Laying 48-inch pipe, \$2.24 per lin. ft.; driving and capping piles, \$12.00 per bent.	16,685 41a	16,685 41	5
Oct. 8, '96,	May 15, '97,	-	Laying 30-inch pipe, \$0.92 per lin. ft.	10,000 00b	4,951 67	6
Oct. 8, '96,	Dec. 1, '96,	-	Laying 16-inch pipe, \$0.45 per lin. ft.	4,900 00b	4,492 82	7
Oct. 8, '96,	May 15, '97,	-	Laying 20-inch pipe, \$0.62 per lin. ft.	10,300 00b	3,437 11	8
. . . . .	. . . . .	. . . . .	. . . . .	\$166,836 33	\$139,133 30	9

**Miscellaneous.**

Mar. 27, '96,	Dec. 12, '96,	-	\$470 per valve, . . . .	\$9,400 00c	\$1,880 00	10
May 26, '96,	July 26, '96,	Aug. '19, '96,	\$42.64 per set, . . . .	1,041 00a	1,041 00	11
May 18, '96,	July 18, '96,	Aug. 19, '96,	\$1.37½ per pound, . . . .	733 59a	733 59	12
June 1, '96,	Nov. 1, '96,	-	24-inch valves, \$197.00; 20-inch, \$141.00; 16-inch, \$74.00; 12-inch, \$55.00.	4,608 00c	1,268 00	13
Oct. 3, '96,	Dec. 1, '96,	-	Price of bridge complete, \$2,497.	2,497 00c	-	14
. . . . .	. . . . .	. . . . .	. . . . .	\$18,279 59	\$4,922 59	15
. . . . .	. . . . .	. . . . .	. . . . .	\$1,054,540 78	\$370,489 24	16



CONTRACTS MADE AND PENDING DURING THE YEAR 1896 — *Concluded.*

## Summary of Contracts.

	Approximate Amount of Contract.	Value of Work done to Time of December Estimate.
Reservoir No. 5, 11 contracts, . . . .	\$800,720 71	\$367,311 59
Nashua Aqueduct, 10 contracts, . . . .	1,246,552 85	327,320 55
Distributing System, 24 contracts, . . . .	1,054,540 78	870,489 24
Total of 45 contracts made by Metropolitan Water Board, . . . . .	\$3,101,814 34	\$1,565,121 38
Reservoir No. 5, uncompleted portions of 11 contracts made by the city of Boston and assumed by the Metropolitan Water Board, . . . .	539,903 54	463,900 74
Total, . . . . .	\$3,641,717 88	\$2,029,022 12

## APPENDIX No. 2.

*Monthly Rainfall, in Inches, during 1896, at Four Places on the Watershed of the Nashua River.*

	LOCATION.			
	Princeton.	Quinepoxt.	So. Clinton.	Sterling.
Elevation above mean sea level (feet), . . . . .	1,060*	690*	310	560*
January, . . . . .	1.96	1.69	2.12	1.63
February, . . . . .	7.52	7.90	7.30	7.41
March, . . . . .	5.76	5.50	4.44	6.22
April, . . . . .	1.80	1.27	1.89	1.66
May, . . . . .	2.37	2.81	2.45	2.25
June, . . . . .	2.56	2.64	2.53	2.75
July, . . . . .	5.10	4.78	4.83	4.23
August, . . . . .	2.71	3.28	2.23	2.26
September, . . . . .	6.94	7.00	7.60	7.69
October, . . . . .	3.49	3.95	3.95	3.49
November, . . . . .	2.83	3.24	2.98	2.91
December, . . . . .	2.27	2.31	2.31	2.01
Totals, . . . . .	45.31	46.37	44.63	44.51

\* Elevations taken from maps of State topographical survey.

## APPENDIX No. 3.

[Chapter 488 of the Acts of the Year 1895.]

## AN ACT TO PROVIDE FOR A METROPOLITAN WATER SUPPLY.

*Be it enacted, etc., as follows :*

## METROPOLITAN WATER BOARD.

SECTION 1. The governor, by and with the advice and consent of the council, shall appoint three water commissioners, who shall constitute the Metropolitan Water Board. Said commissioners shall hold office, one for the term of five years, one for the term of four years and one for the term of three years, beginning with the first Monday in May in the year eighteen hundred and ninety-five; and in the year eighteen hundred and ninety-eight, and annually thereafter, the governor shall appoint, as aforesaid, one member of said board to hold office for the term of three years, beginning with the first Monday in May in the year of his appointment. The governor, with the consent of the council, may remove any member of said board, and may appoint for the residue of the term, in the same manner in which the original appointment was made, a commissioner to fill any vacancy occurring by removal, resignation or otherwise. One of said commissioners shall be always a citizen of Boston, one shall be always a citizen of one of the other cities or towns in the water district hereinafter described, and one shall be always a citizen of this Commonwealth. The chairman of said board shall receive a salary of five thousand dollars a year, and the other members a salary of four thousand five hundred dollars a year.

Commissioners.  
Terms of  
service.Governor and  
council may  
remove.Residence of  
commissioners.

Compensation.

## OFFICERS AND ACCOUNTS.

SECTION 2. The governor shall, as soon as may be after the appointment of said board, and annually thereafter on or before the first Monday of May, designate one of their number to serve as chairman for the ensuing year; said board shall from time to time appoint an engineer, secretary, and such other

Governor to  
designate  
chairman.Board may  
appoint and  
remove officers  
and agents.

**Accounts.** agents, officers, clerks and other employees as said board may deem necessary, shall determine the duties and compensation of such appointees, and may remove the same at pleasure, and may employ counsel; shall at all times keep full, accurate and separate accounts of the doings, receipts, expenditures, disbursements, assets and liabilities of said board, and include an abstract of the same in an annual report to the general court on or before the first Wednesday in January in each year, such report to be numbered as one of the series of public documents; and four thousand five hundred copies thereof to be printed annually.

**Report to the legislature.**

#### METROPOLITAN WATER DISTRICT.

**Board to construct and maintain water works.**

**Metropolitan water district.**

**To supply cities and towns within ten miles of state house.**

**May supply water companies in said district.**

**May supply other cities, towns and water companies.**

**Distribution of money.**

**Delivery of water.**

**SECTION 3.** Said board, acting for the Commonwealth, shall construct, maintain and operate a system of metropolitan water works substantially in accordance with the plans and recommendations of the state board of health, contained in their report to the legislature of the year eighteen hundred and ninety-five, and shall provide thereby a sufficient supply of pure water for the following named cities and towns, and the inhabitants thereof, to wit:—The cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop, which cities and towns shall constitute the Metropolitan Water District; shall secure and protect the purity of said water; shall on application furnish water to any city or town aforesaid that at the time of application owns its water pipe system; shall on application admit any other city or town, any part of which is within ten miles of the state house, into said water district, and furnish water to the same on the terms prescribed by this act for the cities and towns aforesaid, and on such payment of money as said board may determine; shall on application furnish water to any water company owning the water pipe system in any town within said ten miles, on such water company assuming the assessments of the town, if any, and making such payment of money as said board may determine; and may from time to time furnish water to any other city, town or water company, on such payment of money as said board may determine. All payments of money aforesaid shall be distributed to the cities and towns in said district in proportion to the total amount of the annual assessments theretofore paid by them respectively. Said board shall furnish said water to the city,

town or company, by delivering the same into a main water pipe, reservoir or tank of the city, town or company, under sufficient pressure for use without local pumping, unless delivered in some other manner by mutual agreement between the parties interested; and shall have the direction and control of the connections between the metropolitan and local systems. Said board may utilize the fall of water at any dam under their charge, and may thereby produce power or electricity, and may transmit such power or electricity by pipes, wires, or other suitable means, and sell the same, or the right to use such water, by written or other contract, to run for a term not exceeding fifteen years. Any person or corporation authorized by said board shall have all the powers relating to the production, sale and transmission of power and electricity given by this act to said board.

May transmit and sell power or electricity.

May authorize persons and corporations to sell and transmit power and electricity.

#### WATER SOURCES.

SECTION 4. Said board may take, by purchase or otherwise, the waters of the south branch of the Nashua river, at and above a point above the dam of the Lancaster Mills in the town of Clinton, but shall allow not less than twelve million gallons of water to flow from a reservoir above said dam in each week, and such further quantity, not exceeding twelve million gallons a week, as the owner of said mills shall from time to time certify to be necessary for use therein and in other buildings now or hereafter owned by him, for domestic or manufacturing purposes, other than the production of water power, and said board, in regulating the flow of said quantities, shall, as far as practicable, conform to any reasonable request in writing of the owner of said mills; said board may also take the waters of Sandy pond, so-called, in the town of Clinton, and the waters which may flow into and from said pond or river, and the tributaries thereof above said point; may take such water rights as they deem necessary connected with said waters; said board shall forthwith, after taking the waters of said Nashua river, take by purchase or otherwise all real estate which will be submerged or flooded, or submerged to an increased depth, by the construction of the proposed reservoir on the Nashua river hereinafter provided for, and all parcels of real estate above the dam of said reservoir used for mill purposes and owned by the owner of any mill property of which any part will be submerged or flooded by the construction of said reservoir, includ-

May take south branch of Nashua river.

To furnish water for the use of Lancaster Mills.

To conform to request of owner of mills.

May take Sandy pond.

To take real estate submerged or flooded on Nashua river, and machinery used on such real estate.

To take lands, ponds, etc., west of Chestnut Hill reservoir.

To take pumping station at Chestnut Hill reservoir and land surrounding same.

To take Spot pond and land surrounding same and pumping stations thereon.

May take other lands and property.

ing all the machinery used on such real estate and tenements for operatives; shall, on or before the first day of January in the year eighteen hundred and ninety-eight, take all the lands and all the ponds, basins, reservoirs, filter beds, dams, aqueducts, conduits, pumping stations, pipes, pumps and other property held by the city of Boston for the purpose of supplying water or for the purpose of storing or of protecting or preserving the purity of the water, and situated westward of Chestnut Hill reservoir in said city and westward of the intersections of the main pipes to be laid from Chestnut Hill reservoir to Spot pond, with the main pipes which convey water from the Mystic distributing reservoir; also the pumping station at Chestnut Hill reservoir and lands under and surrounding the same, and the pipes and aqueduct leading thereto; also Spot pond, so-called, in or near the town of Stoneham, and the lands under and surrounding the same, now owned by the cities of Malden and Medford and the town of Melrose, or either of them, held for the purpose of water supply or of protecting or preserving the purity of the water, and the pumping stations and pumps thereon; any or all of the aforesaid lands to be taken in fee or otherwise, as said board may determine. Said board may take any other lands in fee, easements, rights and other property that said board may deem necessary or desirable for carrying out the powers and duties conferred upon them by this act.

#### RECORD OF TAKING.

To record description of land taken.

Ponds, lands, etc., taken for the Commonwealth.

To record description of land entered upon for use and purposes for which and time to be used.

SECTION 5. Said board, to take any property by right of eminent domain, shall sign and cause to be recorded in the registry of deeds for the county and district in which the property to be taken is situated, a statement containing a description thereof, as certain as is required in a common conveyance of land, and stating that the same is taken for the metropolitan water works; and upon such recording the ponds, works, lands, waters, easements, rights and other property described in said description shall be taken for the Commonwealth. Said board, upon entering upon any land for the purpose of using the same for carrying out any of the purposes of this act, shall sign and cause to be recorded in the registry aforesaid a statement containing a general description of the land and the purposes for which it is to be used, and the probable time for which the same is to be used, and after they have taken any property under the

right of eminent domain shall notify the owner thereof, and on the request of the owner within three years after such taking shall, within thirty days after such request, furnish him with a plan or description in writing, of his land or other property so taken.

To notify owner of taking by eminent domain.  
To furnish plan, etc., to owner on request.

#### RESERVOIRS.

SECTION 6. Said board shall forthwith, after taking the waters of said Nashua river, construct a storage reservoir upon said Nashua river above said dam of the Lancaster Mills; shall forthwith construct the reservoir in Southborough already partially constructed by the city of Boston, and the dams thereof, and assume and carry out the agreement made by said city with the town of Southborough, and all contracts made by said city relating to the building of said reservoir; may construct other reservoirs, and may raise the level of any pond or reservoir under their charge. Said board may, as they deem desirable in constructing, or raising the level of, any pond or reservoir, raise or alter or discontinue parts of any railroad or public ways, and in case of a railroad shall make such raisings or alterations of the railroad, or construct upon existing or other locations, parts of the railroad to take the place of the parts so discontinued, as, and in such manner as, shall be mutually agreed upon by said water board and the board of directors of the railroad company; and if they cannot agree thereon then as, and in such manner as, shall be determined on the application of either party, in writing, by the board of railroad commissioners of this Commonwealth, who are hereby authorized and directed to adjudicate finally upon the same; and if said water board shall be of the opinion that the making of any such change of grade, alteration or construction requires that lands be taken therefor, said board shall, in the name of the Commonwealth, take such lands and convey the same to the railroad company to be thereafter held and used as the board of directors of such company may determine, and the railroad company may if it desires locate its lines over any lands so conveyed to it, and when said new lines of railroad are completed the railroad company may discontinue the operation of the portions of its existing lines for which the new lines are substituted, and may maintain and operate said new lines of railroad; and said water board shall build the dam of any pond or reservoir constructed, or whose level is raised, as aforesaid, and

Reservoir above dam at Lancaster Mills.

Shall construct reservoir at Southborough and carry out agreements.

May construct other reservoirs.

May alter or discontinue parts of railroads or ways.

Railroad to be constructed as agreed upon.

If cannot agree, application to be made to railroad commissioners.

Railroad commissioners' adjudication to be final.

May take lands and convey same to railroad company.

Railroad company may discontinue portions of existing lines and maintain and operate new lines.

Shall build ways  
in place of those  
discontinued.

Ways to be  
agreed upon by  
board and  
county com-  
missioners.

If cannot agree,  
application to  
be made to  
highway com-  
mission.

To conform to  
requirements of  
boards of health  
in flooding  
burial grounds.

make the raisings or alterations of the public ways as aforesaid, and build in place of the parts of public ways discontinued, as aforesaid, such other reasonable and suitable ways, which shall thereafter be highways, as, and in such manner as, shall be mutually agreed upon by said water board and the county commissioners of the county in which such dam is to be built; or if they cannot agree thereon then as, and in such manner as, shall be determined on the application of said board, in writing, by the highway commission of this Commonwealth, which commission is hereby authorized and directed to adjudicate finally upon the same. Said water board, in flooding or otherwise affecting any burial ground, shall conform to any reasonable requirements relating thereto of the board of health of the city or town in which the same is situated.

#### CHESTNUT HILL RESERVOIR.

To connect  
pumping station  
at Chestnut Hill  
reservoir with  
main water  
pipes.

Contracts of  
Boston with  
Somerville,  
Chelsea and  
Everett shall be  
cancelled.

To connect  
Nashua river  
with reservoir  
at South-  
borough.

SECTION 7. Said water board shall forthwith lay pipes to connect the pumping station at Chestnut Hill reservoir with the main water pipes through which water is now supplied to the cities of Somerville, Chelsea and Everett, and the Charlestown district of the city of Boston, and with Spot pond, and on the first day of January in the year eighteen hundred and ninety-eight the contracts of the city of Boston with the cities of Somerville, Chelsea and Everett, described in, and confirmed by, chapter three hundred and fifty-one of the acts of the year eighteen hundred and eighty-six, for a supply of water, shall be cancelled. Said board shall also forthwith, after taking the waters of Nashua river as aforesaid, connect said river with the tributaries of said reservoir in Southborough.

#### DELIVERY OF WATER TO LANCASTER MILLS.

At least  
1,000,000 gallons  
of water to be  
delivered each  
week day.

To conform to  
request in  
writing of  
owner of mills.

SECTION 8. Said board, until they shall have completed the dam of said proposed reservoir on the Nashua river, and rebuilt the dam of said Lancaster Mills, shall, unless otherwise agreed by said board and the owner of said mills, deliver each week day at, and at the level of, the present top of the dam of said mills at least one million gallons of the water of said river, unpolluted by any acts or doings of said board, conforming in the delivery of said quantity, so far as practicable, to any reasonable request in writing of the owner of said mills.

## CONSTRUCTION OF BUILDINGS, ROADS, ETC.

SECTION 9. Said board in carrying out the powers and duties hereinbefore conferred upon them may construct and maintain buildings, machinery, roads, conduits and aqueducts; may lay and maintain pipes, drains and wires; may alter or change the grades or directions of any water course; may carry and conduct any aqueduct, conduit, pipe, drain or wire under or over any water course, or any railroad, street or other way, in such a manner as not unnecessarily to obstruct or impede travel thereon; may dig up any such road, street or way, and lay, maintain and repair aqueducts, conduits, pipes, wires and other works beneath the surface thereof, conforming to any reasonable regulations made by the mayor and aldermen of cities and the selectmen of towns, respectively, wherein such works are performed, and restoring, so far as practicable, any such road, street or way, to as good order and condition as the same was in when such digging was commenced; said board may enter upon and use the lands of others; may take down dams to such an extent as they may deem necessary for prosecuting their works, and shall rebuild such dams whenever the necessity for keeping them down ceases; shall use such lands and do all work relating to such dams, in a reasonable manner with regard to the interests of the owners thereof, and, so far as practicable, shall heed all reasonable requests made by such owners; and in general may do any other act or thing necessary or proper for carrying out the powers and duties conferred upon them by this act.

May construct and maintain buildings, and lay and maintain pipes, etc.

May carry aqueduct, etc., over water courses, railroads, streets or ways.

May dig up roads, and lay pipes beneath surface conforming to regulations of aldermen and selectmen.

To restore roads after digging up same.

May use lands of others.

May take down and rebuild dams.

To heed requests made by owners of lands and dams.

In general to do all things necessary.

## OPERATION OF WORKS TAKEN FROM BOSTON.

SECTION 10. Said board, on or before the first day of January in the year eighteen hundred and ninety-eight, shall commence the operation of the works taken by them from the city of Boston, and shall thereafter keep the same and all water works constructed by them, and all bridges which they may build across said reservoir upon the Nashua river, and (until they abandon the same by notice in writing to said city) said Chestnut Hill reservoir, safe, and shall have charge of, use, maintain and operate the same, and the Commonwealth shall exclusively be responsible for all damages caused thereby or by any defect or want of repair therein; said board shall have

To commence operation on or before January 1, 1898.

To keep works and reservoirs safe and have charge of same.

Commonwealth responsible for damages.



To have exclusive control of ponds and reservoirs.

May inspect works and fixtures in cities and towns supplied by board. May determine amount of water used and wasted.

the exclusive right and control over all ponds and reservoirs used by them in supplying water, and may order all persons to keep from entering in, upon or over, the waters thereof and the lands of the Commonwealth, city or town, surrounding the same; may inspect the water works and fixtures in any city or town supplied wholly or in part from the works under their charge, and may take all proper measures to determine the amount of water used and wasted and to prevent the improper use or waste of water.

#### PURCHASE AND SALE OF PROPERTY.

Storing, pumping or furnishing water.

City, town or company may sell and board purchase property.

Board may sell and lease property.

Proceeds paid into treasury of the Commonwealth.

SECTION 11. Said board and any city, town or water company aforesaid, may agree with each other for the storing or pumping of water, or the furnishing of the same as aforesaid by either party to any city, town or company; and any such city, town or company may sell to said board, and said board may purchase any property of such city, town or company, whether taken by eminent domain or otherwise, that said board may deem desirable for use in furnishing, as aforesaid, water to any city, town or water company; and said board may sell at public or private sale any property, real or personal, whether taken by eminent domain or otherwise, no longer needed for the water works under their charge, or may from time to time lease any property not then so needed. The proceeds from the operations of said board shall be paid into the treasury of the Commonwealth.

#### EXPENSES AND DAMAGES.

Board shall incur expense.

May agree upon amount of damages.

Damages of town of Clinton.

Damages of persons or corporations by taking of property, change of grade, etc.

SECTION 12. Said board shall incur such expenses as they deem necessary in constructing, operating and maintaining the water works under their charge; may agree with the party injured, upon the damages sustained by any city or town by the taking or use of its lands, ponds, reservoirs, water sources, aqueducts or other property, or the cancellation of contracts, as aforesaid; the damages sustained by the town of Clinton by any interference with its sewerage system or with its drainage rights or privileges; the damages sustained by any person or railroad or other corporation in property by any taking of property or by any change of grade, alteration or discontinuance of any railroad or public way, or by the construction or maintenance of any reservoir or other work, or by the interference with the use of any water, or by any other act or thing

done by said board under this act; shall save harmless the several cities and towns within which any road, street or way is dug up as aforesaid, against all damages for injuries resulting from a defect or want of repair in any road, street or way, caused by such digging up, or by constructing, laying, maintaining or repairing any aqueduct, conduit, pipe, wire or other works therein, and shall furnish without charge to all towns within which any work is done under authority of this act such additional police protection as may be necessary in consequence thereof: *provided*, said board shall have due and reasonable notice of the claims for such damages and opportunity to make a legal defence thereto.

Shall save cities and towns harmless against damages resulting from defect in ways caused by digging up same or laying pipes, etc., thereon.  
Shall furnish police protection to towns.

Proviso.  
Board to have notice of claims and opportunity to defend same.

#### PETITION FOR JURY.

SECTION 13. Said board, city, town, person or corporation, if they cannot agree upon any damages, sustained as aforesaid, may, except in the cases in which payment is otherwise provided for in this act, within two years after the day of the taking of any land, water, easements or other property, or of the use of any property, or of the making of any change of grade, alteration, discontinuance, or location of a way or railroad, or of the doing of any other act or thing causing the damage, file in the office of the clerk of the superior court for the county in which the property taken, used or affected in value by such taking or other act of said board is situated, a petition, signed by the petitioner or the attorney of the petitioner, for a jury to determine such damages, and thereupon, after such notice as said court shall order, the damages so sustained shall be determined by a jury in said court, in the same manner as damages for lands taken for highways are determined. In determining any damages caused by any change of grade or discontinuance of a public way or railroad, or the substitution of a part of a public way or railroad for another part, there shall be taken into account any benefit to the party injured received from this act and anything done thereunder. Interest shall be included in such damages from the date of the taking, or the doing of the act or thing causing the damages, and costs shall be taxed and execution issued as in civil cases, against the Commonwealth in case the petitioner prevails, and against the petitioner in case he does not prevail. Damages for the temporary use of or injury to property may, on the request of the

If cannot agree upon amount of damages, jury may be had if applied for within two years.

Application to be filed in office of clerk of superior court.

After notice, damages to be determined by jury.

Benefit to be taken into account in determining damages.

Interest shall be allowed from date of taking, etc., and costs to be taxed.

Damages for temporary use may be assessed

by monthly  
payments.

petitioner, be assessed by monthly payments, to be continued so long as the property is used.

#### COMMISSIONS MAY BE APPOINTED TO DETERMINE DAMAGES.

Board may agree with owners of certain real estate not owned, April 1, 1895, by the owner of the Lancaster Mills, as to damages, etc.

If they cannot agree, petition may be brought within two years in supreme judicial court for county of Worcester.

After notice and hearing court to appoint commission of three persons.

Court may fill vacancies in commissions. Commissions shall determine damages, specified in petitions.

SECTION 14. Said board, upon the application of the owner of any real estate taken for said proposed reservoir upon the Nashua river, or the owner of any real estate entered upon and used, or of any real estate injured by the taking of the waters of said Nashua river, whether said real estate is within or without the Commonwealth, or of any real estate not taken but directly or indirectly decreased in value by this act or the doings of said board thereunder, situated in the town of West Boylston or in that part of the town of Boylston on the northerly side of said proposed reservoir, or in that part of the town of Clinton on either side of River or Grove streets, between the dam of said proposed reservoir and a line drawn from the northerly corner of Oak and Boylston streets to the northerly corner of said Grove and Nashua streets, and not owned on the first day of April in the year eighteen hundred and ninety-five, by the owner of the Lancaster Mills, may agree with such owner upon the damages to be paid for such taking, injury or decrease in value, and if said board and the owner of any such real estate cannot agree upon such damages, such owner may, within two years after the first taking of water, or of land for said reservoir, under the right of eminent domain, file in the clerk's office of the supreme judicial court for the county of Worcester, in term time or vacation, a petition for the determination of such damages, and thereupon said court, after notice by publication in some newspaper published in the county of Worcester, and in such other manner as the court may order, that all persons entitled to file such petitions will be heard by said court on a day therein named, and a hearing thereon; shall from time to time appoint one or more commissions, each consisting of three disinterested persons, and may after notice and hearing fill any vacancy occurring in any such commission until all petitions referred to it have been heard and determined. Each of said commissions shall, after notice and hearing, determine the damages specified in all such petitions as may be filed as aforesaid and referred to it by said court; and if the owner of any such real estate, no part of

which is taken but which is decreased in value, shall in the petition aforesaid signify his willingness to surrender the real estate, or if there is a mill thereon, the real estate and machinery thereon, to the Commonwealth, the commission shall also determine the value of such real estate, or real estate and machinery, and interest may be included in such damages and in such value at such rate and for such time as the commission may deem just and equitable. Said commissions shall determine the damage to and value of real estate, machinery and business, and from time to time report their determinations on the petitions of such owners to said court. In case any individual or firm owning on the first day of April in the year eighteen hundred and ninety-five an established business on land in the town of West Boylston, whether the same shall be taken or not under this act, or the heirs or personal representatives of such individual or firm, shall deem that such business is decreased in value by the carrying out of this act, whether by loss of custom or otherwise, and unable to agree with said board as to the amount of damages to be paid for such injury, such damages shall be determined and paid in the manner hereinbefore provided. The words "real estate" as used in this section shall include water rights, and in the case of mills all machinery thereon.

Interest may be included in damages.

Commissions to report to said court.

Established business in West Boylston if decreased in value shall have damages determined.

Real estate to include water rights and machinery.

#### PAYMENT OF DAMAGES.

SECTION 15. Said board shall, upon agreeing upon any damages, or upon the acceptance by said court of any determination specified in the preceding section, notify the owner that they will pay the damages, or, in case the petitioner offers to make surrender, if they so prefer, they will pay the value so agreed upon or determined, and if any such owner shall in accordance with such notice and within one year after being so notified, deliver a release of such damages or a deed of the real estate, to and satisfactory to, said water board, said water board shall certify to the treasurer of the Commonwealth the amount to be paid such owner, and said treasurer shall pay the same from the proceeds of the bonds hereinafter provided for. Said water board, or any persons whose property is taken under the right of eminent domain, or entered upon or injured by the taking of said water, if dissatisfied with any determination of damages made by any commission, may at the term on

Board to notify owner that they will pay damages or value agreed upon or determined.

If owner releases damages or gives deed within one year he shall be paid from treasury of Commonwealth.

If board or owner dissatisfied with award of commission, may claim trial by jury.

which such determination is filed in court, or at the succeeding term, claim a trial by jury to determine such damages, and thereupon the damages shall be determined by a jury in said supreme judicial court as provided in section thirteen of this act.

#### PAYMENT TO CITY OF BOSTON AND TOWNS OF BOYLSTON AND WEST BOYLSTON.

Boston to be reimbursed for moneys paid in connection with basins not yet built.

Boylston to be paid \$2,000 a year.

West Boylston to be paid \$12,000 a year.

No tax or other payment to be made.

SECTION 16. The treasurer of the Commonwealth shall, from the proceeds of the bonds hereinafter provided for, reimburse the city of Boston for all moneys paid or that may hereafter be paid by said city for land damages, or otherwise, in connection with the location, building or maintenance of reservoirs or basins not yet built, or for lands taken for the preservation or protection of the purity of the waters of any reservoirs, or basins or of the tributaries thereof, and shall pay as part of the expenses of said metropolitan water works to the town of Boylston the sum of two thousand dollars a year and to the town of West Boylston the sum of twelve thousand dollars a year for the year of and each year succeeding said taking of the waters of said Nashua river, so long as each of said towns remains a municipality, and shall pay no tax or other payment to either of said towns on account of any property held by said water board for the purposes of a water supply.

#### METROPOLITAN WATER LOAN.

Negotiable bonds to be issued not exceeding \$27,000,000.

Principal and interest payable in gold coin.

Payable in not less than thirty nor more than forty years from date.

Interest not to exceed four per cent.

SECTION 17. The treasurer and receiver general shall, from time to time, on the request of said board, issue negotiable bonds in the name and behalf of the Commonwealth, and under its seal, to an amount not exceeding twenty-seven million dollars, designated on the face thereof, Metropolitan Water Loan. Said bonds shall be deemed a pledge of the faith and credit of the Commonwealth, shall be countersigned by the governor; shall have the principal and interest made payable thereon, in gold coin of the United States of America or its equivalent; shall bear interest payable semi-annually on the first days of January and July of each year; shall be registered, or with interest coupons attached; shall be payable within such terms not less than thirty nor more than forty years, and shall bear such rates of interest not exceeding four per cent. per annum, and be issued and disposed of in such amounts and in such modes and at such times and prices as the treasurer and receiver general, with the approval of the governor, shall from

time to time determine. Said treasurer shall, on issuing any of said bonds, establish a sinking fund and determine the amount to be paid thereto each year, sufficient with its accumulations to extinguish the debt at maturity.

Sinking fund to be established.

#### PROCEEDS FROM SALES OF PROPERTY AND BONDS.

SECTION 18. Said treasurer shall apply the proceeds from the sales of property made as hereinbefore provided, and the proceeds from the sales of said bonds, exclusive of the amounts received from premiums, to the payments for the property taken by said board, the payment of the damages aforesaid, and the payment of the expenses of construction of said water works, and the other payments specified in this act, and shall apply any premiums received from sales of said bonds, any assessments hereinafter provided for paid by the cities and towns, and the proceeds from the operations of said board, exclusive of the proceeds from sales of property, to the payment of the interest, sinking fund requirements and expenses of maintenance and operation of said water works, and shall take the balance required for said payments, if any, from the proceeds of said bonds, and shall apply the surplus, if any, to the payment of said interest, sinking fund requirements and expenses, for the following year. Said treasurer shall advance to such person as shall have been designated by said water board and shall have given a bond with sufficient sureties, to be approved by the auditor of the Commonwealth, in the sum of ten thousand dollars, such sums, not exceeding ten thousand dollars at any time, as said auditor may certify to be necessary to enable said board to make direct payment upon the pay rolls and other accounts of said board, and such persons shall, as soon as may be after expending any sum so advanced, and in all cases within thirty days from the receipt of any such sum, file with the auditor a statement in detail of the moneys expended subsequent to the last previous accounting, approved by said water board, and where it is practicable to obtain them, also file receipts or other like vouchers of the persons to whom the payments have been made.

Application of proceeds from sales of property and bonds.

Applications of amounts received from premiums and assessments.

Application of surplus.

\$10,000 to be advanced to person designated by board.

Detailed statement of moneys expended to be filed, also receipts and vouchers of persons receiving same.

#### ESTIMATE AND APPORTIONMENT OF ANNUAL EXPENSES.

SECTION 19. Said treasurer shall in each year estimate the amount, in addition to the premiums from sales of said bonds and the proceeds from the operations of said board, exclusive

Treasurer to estimate annually amount required for

maintenance, interest, etc., and apportion same in proportion to valuation and population.

of the proceeds from sales of property, required during the year to pay the interest, sinking fund requirements, expenses of maintenance and operation of said water works, and shall apportion to the city of Boston the proportion of such amount that the valuation of said city for the preceding year bears to the total of all such valuations of all cities and towns in said water district: *provided, however*, there shall be included only one sixth of the total valuation of any such city and town which has not reached the safe capacity of its present sources of supply in a dry year, as determined by said water board and certified to said treasurer, and has not made application to said board for water, and the remainder to the other cities and towns in said district, one third in proportion to their respective valuations and the remaining two thirds in proportion to their respective populations, including however only one sixth of the total valuation and one sixth of the total population of any such city and town which has not reached the safe capacity of its sources or of the sources of supply of the water company by which a town is supplied, or has not made application for water as aforesaid; and *provided, further*, that any city or town assessed upon its full valuation and population, which furnishes a part of its water supply from its own works or receives a supply from a water company, shall be allowed and credited in its apportionment with a sum equal to twelve dollars for each million gallons of water furnished as aforesaid, as determined by said water board and certified to said treasurer, and *provided, further*, that no such amount shall be so apportioned until the year eighteen hundred and ninety-eight, and in said year only the amount of three hundred thousand dollars shall be apportioned, and the sums of money expended by the state board of health under chapter four hundred and fifty-nine of the acts of the year eighteen hundred and ninety-three and chapter four of the resolves of the year eighteen hundred and ninety-five, and in the succeeding years the said amount of three hundred thousand dollars and two hundred thousand dollars additional for each year thereafter shall be so apportioned until the entire amount required as aforesaid is reached, and thereafter such entire amount shall be so apportioned. Said treasurer shall in each year notify each city and town of the amount of its assessment, and the same shall be paid by the city or town into the treasury of the Commonwealth at the time required for the payment and as part of its state tax.

One sixth only of valuation and population in certain cities and towns.

Cities and towns assessed upon full valuation and population furnishing part of water supply to be allowed certain sums.

First apportionment to be made in 1898.

Cities and towns to be notified of assessments.

To be paid as part of state tax.

## CONTROL AND DISTRIBUTION OF WATER.

SECTION 20. The water board, water commissioners or superintendent of any city or town in the metropolitan water district, shall for their respective cities or towns, on and after the first day of January in the year eighteen hundred and ninety-five, have the charge and control of the water sources, water and water works owned and used by said city or town and not taken or used by said metropolitan water board as herein provided. Said water board, water commissioners or superintendent shall distribute and control the use of the water so furnished, and apply meters and extend the pipes and other work as said water board, water commissioners or superintendent may deem expedient; shall keep the pipes, fixtures and other works under their charge in good condition and repair, but shall not expend in any year more than the amount appropriated by the city or town therefor. Said water board, water commissioners or superintendent, with the approval of the mayor or selectmen, shall determine the rate to be paid for water by the owner of the premises to which the water is furnished, or by the person or persons using the water: *provided, however,* that the minimum rates to be paid for water, and the premises to which the high service supply shall be furnished, shall be subject to the approval of said metropolitan water board. Any water board, water commissioner or superintendent as aforesaid shall for the water works under his charge do all the acts and things relating to buildings, machinery, roads, conduits, aqueducts, pipes and drains, which said metropolitan water board is authorized to do for the water works under their charge, and may take lands therefor, in fee or otherwise, and shall do all such acts and things and make all such takings in the manner in which said metropolitan water board are authorized to do similar things, and the damages sustained shall be recovered of, and paid by, the city or town for which such water board, water commissioners or superintendents are appointed or elected, in the same manner as damages caused by similar acts of said metropolitan water board are recovered of, and paid by, the Commonwealth.

Water boards, etc., of cities and towns to have charge of works not taken by board.

Not to exceed appropriations by city or town.

Water rates to be determined.

Board to approve rates.

Water boards, etc., of cities and towns to do all things relating to water supply.

Damages shall be paid by city or town.

## APPLICATION OF INCOME.

SECTION 21. The income received in each city or town from the water works under the charge of its water board, water

Cities and towns to apply income to





payment of  
expenses,  
interest, etc.

commissioners or superintendent, shall be applied to the payment of the expenses of maintenance and operation incurred by said water board, water commissioners or superintendent; the interest and sinking fund requirements of all bonds, notes or scrip of the city or town issued on account of the water works of such city or town; the assessment of the city or town to be paid to the treasurer of the Commonwealth as hereinbefore provided; the expenses of the extension of the works; and the balance, if any, as the city or town may determine. If such income in any year shall not be sufficient for said payments the balance required therefor shall be raised by taxation or by loan, as the city or town may determine; and the city or town is hereby authorized to assess such taxes and make such loans without further authority from the legislature.

Balance as city  
or town may  
determine.  
If income is  
insufficient  
balance to be  
raised by  
taxation or  
loan.

#### WORCESTER AND CERTAIN TOWNS MAY TAKE WATER.

City of  
Worcester and  
certain towns  
may take water  
from Nashua  
river under  
certain con-  
ditions.

SECTION 22. The towns of Clinton, Sterling, Boylston, West Boylston, Lancaster, Holden, Rutland, Princeton, Paxton and Leicester, and the city of Worcester, may take from the south branch of the Nashua river, above the dam of the proposed reservoir on said river, so much of the water thereof as they have already been or may hereafter be authorized by the legislature to take, for supplying their inhabitants with water, and in case either of the towns of Lancaster, Holden, Rutland, Princeton, Paxton or Leicester, or the city of Worcester, shall so take water, it shall pay to the Commonwealth, to be paid into the sinking funds for said bonds, a fair proportion of the cost incurred by the Commonwealth for said water and for the construction, maintenance and operation of said works, the same to be determined by the engineer of said board and an engineer to be appointed by the city or town, and if they cannot agree, the proportion shall be determined by a master to be appointed by the supreme judicial court on the petition of either party interested, and the report of such master made and accepted by said court shall be final and binding on all parties.

If water is  
taken, propor-  
tion of cost to  
be paid to the  
Common-  
wealth.

If cannot agree  
on amount,  
master to be  
appointed.

#### USE OF WATER IN DISTRICT RESTRICTED.

No city or town  
in district to use  
water for  
domestic  
purposes except

SECTION 23. No city or town, any part of which is within ten miles of the state house, or any water company owning a water pipe system in any such city or town shall, except in case

of emergency, use, for domestic purposes, water from any source not now used by it except as herein provided or as shall be hereafter authorized by the legislature. If any town or towns in said district shall take the franchise, works and property in such town or towns, of any water company, the compensation to be allowed and paid therefor shall not be increased or decreased by reason of the provisions of this act. No town in said water district now supplied with water by a water company owning the water pipe system in such town, shall introduce water from the metropolitan water works until it shall first have acquired the works of such company.

when authorized by legislature.

No town to introduce water from metropolitan supply till works of water company have been acquired.

#### SANITARY PROTECTION OF WATER.

SECTION 24. The state board of health is hereby authorized and required to make rules and regulations for the sanitary protection of all waters used by the metropolitan water board for the water supply of any city, town or water company aforesaid, and to transfer and deliver to said water board, such plans, maps and other information in their possession as will assist said board in carrying out the provisions of this act.

Rules for protection of water used by board.

Plans, maps and other information to be transferred to board.

#### IMPROPER USE OF WATER PROHIBITED.

SECTION 25. No person shall take or divert any water of a water supply of any city or town in said water district from any water source, reservoir, conduit or pipe used for supplying such water to, or in any such city or town, or occupy, injure or interfere with any such water, or with any land, building, aqueduct, pipe, drain, conduit, hydrant, machinery or other work or property so used, and no person shall corrupt, render impure, waste or improperly use, any such water.

Water not to be diverted.

Buildings, machinery, etc., not to be injured.

#### PRECEDING SECTION NOT TO APPLY IN CERTAIN CASES.

SECTION 26. The provisions of the preceding section shall not apply to any person in taking or diverting any such water or interfering with or occupying any water, land or works therein described, by permission of said metropolitan water board, or the water board, water commissioners or superintendent of any city or town having charge of the land, water or work; nor to the individual inhabitants of any city or town within the watershed of any water supply used by said metropolitan water board, or by any city or town aforesaid, in taking

Not to apply where water, land, etc., are taken or occupied by permission of board.

Nor to inhabitants of any city or town taking water for ordinary uses.

UNIVERSITY OF MICHIGAN



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